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FEBRUARY 1, 1961 Vol. 51, No. 5

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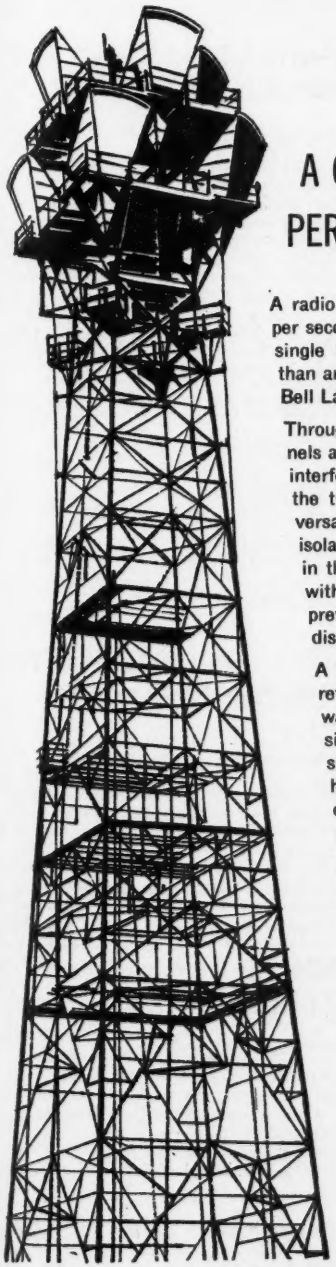

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NEW CIVIL PROGRAM AT M.I.T.

Major changes in the undergraduate program in Civil Engineering at the Massachusetts Institute of Technology have been announced by Dr. John B. Wilbur, head of the department.

The changes have been incorporated into the curriculum for classes which began September 19. Spurring the important revisions of the civil engineering curriculum is the Ford Foundation grant for $9,275,000 to M.I.T. for making extensive advances in engineering education. Announced in October, 1959, the grant is now supporting a long-range program of development and innovation in the entire School of Engineering.

Modern physics, thermodynamics, fluid dynamics, electrical engineering, particulate mechanics (the study of particles such as those in soils), and materials engineering are among the subjects that are offered. Additional requirements include statistical theory and mathematical methods in civil engineering, the latter including numerical methods, operations research and computer methods.

In addition, the department has developed subjects in cooperation with other M.I.T. departments covering such fields as geotechnical science, biological factors in engineering, and social and political factors in engineering.

Do You Know

► That ASEE will now sponsor, co-sponsor, cooperate, or approve projects? The Projects Management Group established the following definitions because of the variety of requests coming to ASEE for participation in programs. *Sponsorship* of a project includes the appointment by ASEE of the Advisory Committee, approval of the director, and operation of the budget. *Joint sponsorship* of ASEE and another agency means that they jointly appoint the advisory committee, jointly approve the director, and jointly agree upon an appropriate agent to operate the budget. *Cooperation* involves approval by PMG and the appointment of a representative to the advisory committee who shall report at appropriate intervals and make a final report to ASEE. *Approval* pertains to a project operated by another agency and means only an expression of judgment by PMG as to the project's merit within the field of engineering education which might assist the agency in obtaining other sponsorship or attracting attendance of ASEE members. All future proposals coming to ASEE will be interpreted in the light of these definitions.

► That PMG has three members in addition to those listed in the November JOURNAL? Apologies are extended to W. R. Marshall, Jr., Glenn Murphy, and W. W. Hagerty for not including their names in the November "Do You Know" and the December list of committees. The Yearbook-Directory listing will be correct.

► That the papers presented at the 1960 workshop on solid state electronics at Purdue University have been published? The papers presented at the jointly sponsored meeting of the EE Division of ASEE and the IRE Professional Groups on Education and on Electronic Devices are published in the IRE *Transactions on Education*, Vol. E-3, No. 4, December, 1960. The cost of IRE members is $2.25, to libraries and colleges $2.25, and to all others $4.50.

► That ECRC now has a committee on Interdisciplinary Research? C. C. Chambers of the University of Pennsylvania is the Chairman and the members are R. E. Burroughs, Renato Contini, C. A. Dunn, and D. A. Holiday of the University of Chicago.

► That the interior of ASEE's little headquarters house has been remodeled to give more work space? The Assistant Secretary now has an office of his own, a washroom was moved to the basement, the basement provides adequate storage, and removing an upstairs wall converted a hallway into badly needed work area. In addition, all the interior walls were painted. The headquarters staff is thankful to the University of Illinois for the improvements.

► That about one out of every three appearing on the program for the 1960 Annual Meeting were from non-educational institutions? About forty came from industry and about twenty-five from industrial laboratories, government laboratories, and governmental offices of various types. The titles were top-flight, such as president, director, vice-president, manager, regional director, chairman, curator, head, chief engineer, industrial marketing analyst, editor, consultant, assistant superintendent, and chief mathematician. This really was an imposing array of talent and clearly indicates that industry is welcome to participate in the deliberations of ASEE, does express its opinions, and does have a voice in fashioning engineering education.

► That a subcommittee to study the ROTC problem has been established by the Education and Accreditation Committee of ECPD? The action results from a meeting of representatives of the Army with the E & A Committee. Apparently there is the mistaken idea that ECPD is against ROTC. Another objective of the Committee is to improve public relations to correct this erroneous belief.

► That curricula for which support is received from government funds supporting vocational education are no longer excluded from consideration for accreditation of technical institute curricula by ECPD? The change was made because of the belief that the general principle of ECPD should be to look at programs for content and to avoid the exclusion of higher education curricula at institutions which had received government support under Title 8 of the National Defense Education Act.

► That a few observations of the EJC team visiting Russia to study manpower utilization have been released? Not more than 20% of USSR students are directly admitted to higher education. The remaining 80% must spend two years in industry before being permitted to continue their education. The 20% admitted directly must spend 1.3 years in practical work in industry as part of their education. As a result, theoretical and mathematical content is above that generally given in the bachelor programs in U. S. colleges of engineering. Also, the mathematical content of the course work in Soviet technicums is above that of practically all U. S. technical institutes. Only about 1,000 of the 14,000 to 16,000 graduates of U. S. technical schools are of the quality of those produced by the technicums of the USSR—250,000 graduates annually. Although the USSR is graduating 108,000 engineers annually, it is not uncommon for an engineer on his first assignment to serve as a technician or even in the worker category. About one-third of the students in the engineering institutes and technicums are women.

► That "The Truth about Soviet Education" is an article in the *U. S. News & World Report* of July 4, 1960? The article sets forth the view of two vocational educators, Mark Nichols and H. H. London, former presidents of the American Vocational Association. Particularly significant comments are that since the change in the educational system in 1958 the objective of Russian education is to train every individual as much as possible for production efficiency in terms of his native ability and the needs of society. This seems to be a shift from emphasis on higher education toward more emphasis on vocational training. The reason for the shift apparently is the lack of capital and consumer goods—a great lack—and the need for training productive workers to make consumer goods available in larger quantities. Vocational and technical education is looked upon as means of providing the skilled manpower that will enable them to turn out both capital and consumer goods and thus surpass America. They have recognized that although science, mathematics, and languages are important to an educated people, you just cannot run a competitive economy with everybody trained for a job at the top.

► That a Social Sciences Division has been established by NSF? In making the announcement Dr. Allen T. Waterman, Foundation Director, said, "Elevation of the Office of Social Sciences to divisional status recognizes the insistent need of supporting more fundamental studies in the social sciences, particularly in the face of diminishing support from other sources." For the past two years the funds granted for support of the social sciences have been only about one-fifth of the funds requested in the form of proposals. The first grant for research in the Social Sciences by NSF was made six years ago; for fiscal 1961, $3.4 million were allocated to support about 130 grants. Dr. H. W. Riecken, formerly head of the Office of Social Sciences and on leave of absence from the University of Minnesota, has been appointed Assistant Director of the new Division.

► That ECRC has requested NSF to establish a division of engineering and thus separate the fundamental research in the engineering sciences from that in the areas of mathematics and physics? It behooves everyone to lend as much support to this movement as possible.

► That Dr. F. Philips Pike is the Program Director for Engineering Sciences in the Mathematical, Physical, and Engi-

neering Sciences Division of the NSF? Dr. Pike served as Professor of Chemical Engineering at North Carolina State College before coming to the Foundation in February of 1960 as Assistant Program Director for Engineering Sciences. Dr. C. A. Whitmer has been appointed as Head, Course Content Improvement Section. He is on leave from Rutgers University.

► That the David Taylor Model Basin administers a "Fundamental Hydromechanics Research Program" for the Bureau of Ships? Under it, fundamental research in hydromechanics by non-government laboratories, universities, and/or commercial organizations is financially supported if the research is considered of importance to the Navy. Areas of interest are resistance, propulsion, stability, control, sea-keeping characteristics, noise radiation, and special problems of all types for water-borne craft. Proposals should be in the hands of S. F. Crump, Department of the Navy, David Taylor Model Basin, Washington 7, D. C., prior to March 15, 1961. The contracts ultimately drawn will be made for the Office of Naval Research for the period October 1, 1961 through September 30, 1962.

► That a contest of papers on scientific administration is a part of the Third Inter-American Management Conference to be held in Mexico City, March 6–11, 1961? The general topic is "Scientific Management and Its Responsibility in Bettering the Standards of Living in the Americas." First prize consists of $1200 in cash, a gold medal, and a diploma; second prize is $800, a gold medal, and a diploma; and third prize is a gold medal and a diploma. Rules, regulations, etc. can be obtained from, Confederacion Patronai de la Republica Mexicana, San Juan de Letran 13, Mexico.

► That a survey of the various projects in the improvement of curriculum and in the content of courses in science and mathematics is contained in *Science Education News* for September 1960? "SEN" is published by the AAAS, 1515 Massachusetts Ave., N.W. Washington 5, D. C.

► That the Bureau of Standards is building a new $100 million center at Gaithersburg, Maryland? A major reason for the new facilities is the fact that the Bureau of Standards at the present time is capable of measuring only to 0.00001 inch on a .04-inch hole, whereas many industries can hold accuracies of a millionth of an inch on a hole down to .08 inch in diameter. There also will be a new machine capable of measuring rocket thrust up to a million pounds, something which far exceeds the present means of measurement.

► That all freshman registration increased 11.4% over last year in 856 institutions included in the enrollment survey of *School and Society*? Those training to be teachers increased 13.7%, Arts and Sciences 12.7%, Engineering 3.4% (as compared to a loss of 4.7% last year and 7.6% the year before), Agriculture 1.3%, Business Administration 11.0%. Registration of freshman women increased 13.9% whereas the gain for men was 9.6%. The large universities under public control are having student bodies increase about twice as fast as similar private universities.

► That 72 technicians were employed for every 100 engineers and scientists in January 1959? About 250,000 of the 550,000 total were classified as engineering and physical science technicians and over 195,000 as draftsmen. About 28% of the total are engaged in research and development, the ratio of technicians to engineers and scientists there being only 56 per 100. These data also come from the NSF report "Scientific and Technical Personnel in American Industry."

W. Leighton Collins
Secretary

The AEC–ASEE Summer Institutes in Nuclear Science and Engineering

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Introduction

Following World War II, there was little encouragement of educational institutions to introduce nuclear engineering studies into their programs. The Atomic Energy Act of 1946 restricted the dissemination of information concerning nuclear fission and, in particular, its use for power and other industrial purposes. Except for those educational institutions where there were faculty members who had participated in the Manhattan project, little progress was made in the introduction of nuclear studies into curricula. This was particularly true of most schools of engineering. Except for some physicists and chemists, few members of engineering faculties had ever had the opportunity of either studying nuclear physics or of working at one of the National Laboratories where atomic energy research and development were under way.

In 1954, Congress revised the earlier Act and removed certain restrictions relative to the dissemination of information about nuclear fission and its use in the development of power and for other industrial purposes. The shortage of teachers knowledgeable in the nuclear field, however, continued to hold up the introduction of nuclear studies in many engineering schools. To meet this situation, the Atomic Energy Commission, the National Science Foundation and the American Society for Engineering Education jointly sponsored a Summer Institute in Nuclear Science and Technology for faculty members from engineering schools. The first Institute was offered by the International School at Argonne in the summer of 1956, and covered the basic science and technology of nuclear engineering in a period of eight weeks. Its cost was borne by the A.E.C. Each faculty member attending received one month's salary from his home institution. In addition, the N.S.F. agreed to provide the necessary additional monies to pay him an equal additional month's salary (but not to exceed $750) plus his travelling expenses from his home to Argonne and return. The number of qualified applicants exceeded the capacity (60) of the International School to such an extent that the Brookhaven National Laboratory at the request of the A.E.C. undertook to provide a similar Basic Institute for 30 faculty members under the same conditions.

The same two Basic Institutes were again offered in the summer of 1957, except that the A.E.C. undertook the costs paid in the previous year by the

A report by the ASEE Subcommittee on Evaluation of Summer Institutes. Presented at the ASEE Annual Meeting, June, 1960, at Purdue University.

N.S.F. In addition, 4 Advanced Institutes were also provided for those faculty members who had either attended the previous Basic Institutes or had had the equivalent in experience.

There follows a list of the Summer Institutes sponsored by the A.E.C. and the ASEE and offered to faculty members of engineering schools.

10 Basic Institutes in Nuclear Science and Engineering:

1956 and 1957 Argonne National Laboratory
1956 and 1957 Brookhaven National Laboratory
1958 and 1959 Cornell University with Brookhaven National Laboratory
1958 and 1959 North Carolina State College with Oak Ridge National Laboratory
1958 University of California at Berkeley with Radiation Laboratory
1958 Purdue University with Argonne National Laboratory

11 Advanced Institutes in the following subjects:

1957, 1958 Nuclear Metallurgy—Ames Metallurgical Laboratory
1957, 1958, 1959 Chemical Processing—Hanford Atomic Processing Operations
1957 Theoretical Reactor Physics—Oak Ridge National Laboratory
1957 Use of Teaching Reactors—Argonne National Laboratory
1958 Reactor Instrumentation and Control—Argonne National Laboratory
1958 Reactor Theory and Practice—University of Michigan
1959 Special Topics in Reactor Operation and Design—University of Michigan
1959 Specialized Nuclear Studies—Argonne National Laboratory

In the fall of 1959, the American Society for Engineering Education undertook to evaluate the contribution made by the above Institutes to engineering education. Questionnaires were mailed to the Deans of 147 schools from which 372 faculty members had attended one or more summer institutes. This report deals with the replies received from 92 institutions (62.5%) including reports on 290 (78%) faculty attendants. It consists of two sections; the first gives an analysis of statistics, the second, the conclusions drawn.

Statistics

I. *Evaluation of Institutes by the Deans of Schools of Engineering, or by Their Designees*—based on their answers to "Appraisal of the contributions the summer institute programs have made to your nuclear education program"

Of the 92 institutions submitting answers:

63 (68.5%) have indicated that the institutes were of definite assistance—i.e. that they stimulated the introduction of nuclear studies and that they made programs in nuclear science and engineering available at a much earlier date (by as much as 2 years, or more) than would have been possible without the training provided by the Institutes.

14 (15.2%) indicate that the institutes have been of some value.

Only 4 (4.3%) imply that the institutes have been of little, or no value.

11 (12.0%) did not submit answers to the above question. Of these, however, 7 (7.6%) are granting master's degrees in Nuclear Science or Engineering and should probably be included in the first category above.

II. *Programs in Nuclear Science and/or Engineering as Described in Answers to the Questionnaire*

1. 36 institutions award special degrees in Nuclear Science or Engineering; most of these also offer electives in nuclear science and/or engineering to candidates for conventional degrees.

4 grant bachelor's degrees—	193 students enrolled
33 grant master's degrees— (3 more schools will offer programs for master's degrees in 1960–61)	466 students enrolled
8 grant doctor's degrees— (2 more schools will offer programs for doctor's degrees in 1960–61)	41 students enrolled
	700 student candidates for special degrees

2. In addition to the above 36, thirteen institutions offer majors in nuclear studies to students who are candidates for certain conventional degrees already established.
3. Of the remaining 43 institutions:
   - 10 provide a number of minors or electives in nuclear science and engineering
   - 30 offer one to three courses, but not very much. Many of these are apparently just getting programs in nuclear studies underway; several have already formulated additional courses.
   - 3 gave no real information on this subject.

III. *Evaluation of Institutes Based on Effect upon Individuals who Attended Them*

Reports were received on 290 individuals who have attended Summer Institutes. The great majority (more than 80%) of these indicate the following range of effectiveness for these institutes: "enormously beneficial," "invaluable," "stimulating," "provided knowledge for counselling on curriculum problems," "better understanding," "improved background for teaching," "broadening," etc.

In spite of the fact that 55 individuals have been checked as making "little or no contribution" in the way of current nuclear activities at their home institutions, 48 of these same individuals are in the 80% group referred to above in respect to the effect of the Institutes upon their personal development.

The following two paragraphs set forth the extent to which attendants at the Institutes are currently contributing to nuclear activities at their home institutions.

1. *Basic Institutes Only.* Reports on 179 staff members who have attended basic institutes *only* (43 of them in the summer of 1959) indicate that:

50	(28.0%)	conduct courses in nuclear science or engineering.
22	(12.3%)	in addition to the above, give parts of courses in nuclear science or engineering.
24	(13.4%)	in addition to the above, have introduced significant nuclear material into established courses.
5	(2.8%)	in addition to the above, will give courses in 1960–61.
7	(3.9%)	in addition to the above, are members of Nuclear Studies Committees.
7	(3.9%)	in addition to the above, have administrative or research duties primarily.
20	(11.2%)	in addition to the above, left home institution and/or are pursuing graduate studies in the nuclear field.
38	(21.2%)	in addition to the above, are making little or no current contribution in the field of nuclear studies.
6	(3.3%)	in addition to the above, no information given.
115	(64.2%)	appear to be making active use of their Institute experiences at their home institutions. (Sum of first six rows above.)

2. *Advanced Institutes.* Reports on 111 staff members who have attended advanced institutes, of whom 43 have also attended Basic Institutes, indicate that:

71	(64.0%)	give courses in nuclear science or engineering.
13	(11.7%)	in addition to the above, give parts of courses in nuclear science or engineering.
6	(5.4%)	in addition to the above, introduce significant nuclear material into established courses.
1	(0.9%)	in addition to the above, will give course in 1960–61.
2	(1.8%)	in addition to the above, are members of Nuclear Studies Committees.
1	(0.9%)	in addition to the above, has administrative duties primarily.
6	(5.4%)	in addition to the above, have left home institution and/or pursue graduate studies.
7	(6.3%)	in addition to the above, have made little or no contribution.
4	(3.6%)	in addition to the above, no information given.
94	(84.7%)	appear to be making active use of their Institute experiences at their home institutions. (Sum of first six rows above.)

IV. *Statistics re the Demand for Future Institutes.* 92 schools have replied as follows:

1. Basic Institutes:
   Number of staff to attend in 1960–54
   Number of staff to attend later –87 plus 15/year
2. Advanced Institutes:
   Number of staff to attend in 1960–49
   Number of staff to attend later –129 plus 12/year

The following subjects for Advanced Institutes and the number of staff to attend same have been proposed and are listed in order of the demand indicated:

Reactor Instrumentation and Control	–21
Applications of Isotopes	–19
Radiation Damage	–16
Reactor Design	–16
Fusion	–15
Heat Transfer	–14
Chemical Processing	–14
Nuclear Metallurgy	–14
Experiments with Reactors	–10
Reactor Physics	–10
Advanced Reactor Theory	– 8
Laboratory Equipment and Experiments	– 7
Shielding	– 6
Reactor Engineering	– 6
Reactor Materials	– 5
Health Physics	– 4
Neutron Physics	– 3
Fluid Mechanics	– 3
Magnetohydrodynamics	– 3
Radiochemistry	– 3
Nuclear Power Economics	– 2
Power from Systems other than Mechanical	– 2
Linear Accelerators	– 2
Waste Disposal	– 2
Breeder Reactor Systems	– 2
Content and Organization of N. E. Educ. Program	– 2
Nuclear Engineering Studies (Advanced)	– 2
Reactor Safeguards Analysis	– 2
Transuranic Elements	– 1
Gas Cooled Reactors	– 1
Mass Transfer	– 1
N. E. for Technicians	– 1
Nuclear and Radiation Chemistry	– 1
Hot Metallographic Techniques	– ?
Neutron Diffraction Techniques	– ?

Conclusions

Except where otherwise implied, these conclusions are drawn from the statistics given above.

I. The Summer Institutes have proved of value to 90% of the 92 institutions that replied to the questionnaire. For 75% they appear to have made possible the introduction of nuclear studies into curricula at a much earlier date than would have occurred otherwise. Only in the case of 4% of the institutions is there indication that the Summer Institutes proved of little or no value. Indeed, the lack of any explicit adverse criticism is remarkable.

II. Forty-nine, or 53%, of the institutions replying to the questionnaire ap-

pear to have developed well established programs in nuclear studies by the fall of 1959. Almost three-quarters, or 36, of these institutions are offering curricula leading to one or more special degrees in nuclear science and/or in nuclear engineering. The remaining 13 offer majors in nuclear studies which may be taken by candidates for the more conventional degrees.

Most of the remaining institutions, 40, or 43.5%, provided minors or electives in nuclear science and/or engineering. These institutions are at an earlier stage in the development of their curricula in nuclear studies. Many of them have planned additional courses; several expressed the hope that the Summer Institutes will be continued.

The number of students enrolled as candidates for special degrees was indicated as 700. Of these, 180 were awarded degrees in 1959; the remaining 520 are candidates for degrees in either 1960 or 1961. These numbers are minima since several institutions did not supply complete figures in their answers to this question. The data given, however, indicate an increasing number of candidates for these special degrees year by year. Moreover, these numbers do not include any candidates for conventional degrees who are taking majors in nuclear studies. The dean of one engineering school writes that "during the past two years over 1,000 students have been enrolled in the 20 graduate courses in nuclear studies now offered to candidates for master's degrees." One concludes from such evidence as this that the number of students now enrolled in these 92 institutions who are taking nuclear studies must be in the thousands. It further appears that many of them owe their present opportunity to take courses in the nuclear field to the Summer Institutes and the equipment awards that have been provided by the A.E.C.

III. In the vast majority, over 80%, of the reports on individuals, the influence of attendance at the Summer Institutes has been described as "enormously beneficial," "invaluable," "stimulating," and as "providing knowledge for counselling on curriculum problems," "better understanding," "improved backgrou for teaching," "broadening," etc. For eight of the 55 individuals who ha been checked as making "little or no co tribution" in the way of current activiti at their home institutions were include in this category.

As might have been expected, the de gree of value an individual obtained fro a Basic Institute appears to have de pended upon the breadth of his profes sional interests and his attitude; and th extent of his contribution after returnin to his home institution, upon not only hi initiative but also the readiness of his in stitution to introduce new subject matte into curricula and to provide the labora tory equipment therefor.

The survey nature of the Basic Insti tutes naturally did not provide those wh only attended them with the depth o background that is desirable for the con duct of specialized courses in the nuclea field. The fact is noteworthy, however that 50 of these attendants, or 28%, now (1959–60) conduct courses in the nu clear field at their home institutions and that an equal number are responsible for parts of courses or have introduced sig nificant nuclear subject matter into con ventional courses. A significant numbe of the 90 attendants at the first Basic Institutes, given in the summer of 1958 were of high professorial rank; their other responsibilities would not permit many of these to conduct nuclear courses. There is indication, however, that, in their administrative capacities, several have assisted in the introduction of nu clear studies at their institutions. Cer tainly, these Basic Institutes appear to have provided an understanding of the importance and scope of the field of nu clear engineering that has stimulated the introduction of nuclear subject matter into curricula.

The Advanced Institutes appear to have been very successful in encouraging attendants to conduct specialized courses. Seventy-one, or 64%, of these attendants now conduct courses in the nuclear field; an additional 17% are responsible for parts of courses or have introduced significant nuclear subject matter into conventional courses.

IV. There exists a demand for the continuance of the Summer Institutes, particularly for those of an advanced character. While there are still institutions which no doubt could profit from a repetition of the Basic Institutes in the summer of 1961, the need for such Institutes is diminishing. In addition to those who have attended Basic Institutes, there is, each year, an increasing number of scientists and engineers who are awarded master's degrees with at least majors in nuclear studies. While many of these will be recruited by industry, some will prefer to teach. There is, therefore, an increasing availability of candidates with master's degrees to meet the staff needs of engineering schools in the field of nuclear science and engineering.

With respect to the Advanced Institutes, the situation is somewhat different. Many engineering schools have indicated their desire to have certain members of their staff obtain more background in the nuclear aspects of their particular fields of science and engineering. In the subjects where the indicated demand is sufficiently high, some Institutes should be provided in 1961, and probably in 1962.

Many participants in Summer Institutes have emphasized the great value to them of the opportunity to meet their colleagues from other institutions and to discuss with them their mutual problems. Since many schools of engineering are in the early or developmental stage of curricula dealing with nuclear science and engineering it would seem timely to provide for regional conferences for those responsible for programs in the nuclear field. Summer Institutes of one or two weeks' duration at which the problems and criteria of value in the field of nuclear education could be discussed would be, we think, welcomed.

V. The past ten years constitute an interesting chapter in the history of engineering education. There has been a renewed demand for greater emphasis on basic science and mathematics and for more attention to the important social implications of engineering developments. The increased recognition of the vital importance of basic research has resulted in a higher evaluation of graduate work and advanced degrees. The application of new knowledge to products and processes of economic importance has continued to be accelerated. The young engineer today faces a world of greater dynamic change than ever before. To function effectively he needs to be an *educated* man in every real sense of the word. Training in a specialized technology will not suffice; it tends to limit both his opportunities and his ultimate professional attainments. In no field has this been more evident than in that of the development and use of nuclear energy. In the past four years the Summer Institutes have brought this message to about 400 faculty members of 120 schools of science and engineering. These Institutes, sponsored by the A.E.C., the ASEE and, in part, by N.S.F., may well prove to have played a significant role in this important chapter of American engineering education.

ADMINISTRATION INSTITUTE

An Institute on College and University Administration will be held at the University of Michigan, June 26–30, 1961. The program will focus upon principles and methods of organization and administration, including discussion of the decision-making process, human relations, and basic skills of administration. The staff will include the faculty of the Center for the Study of Higher Education and other resource persons.

The Institute, in its seventh year of operation, is intended for presidents, deans, business officers, etc.; the membershsip is limited to sixty persons. Information may be secured from the director, Algo D. Henderson, The University of Michigan, Ann Arbor, Michigan.

Evaluation of the AEC Equipment Grant Program in Nuclear Engineering and Science

Report of the Equipment Grants Evaluation Subcommittee of the ASEE Committee on Nuclear Engineering Education

R. J. MARTIN

E. A. TRABANT

C. E. DRYDEN, CHAIRMAN

Summary

This paper presents the results of a comprehensive survey conducted by the Committee on Nuclear Engineering Education of the American Society for Engineering Education. The purpose of the survey is to evaluate the impact of grants-in-aid awarded by the U. S. Atomic Energy Commission to colleges and universities for the purchase of nuclear equipment to assist educational programs in nuclear engineering and science. The survey has shown that the grant program has been well administered and that the equipment provided by the grants has proved to be extremely valuable to the recipient institutions in the conduct of their nuclear educational programs. Survey questionnaires were returned by 79 of the 125 institutions which have received grants for nuclear equipment from the Educational and Training Branch of the Reactor Development Division of the AEC. During the period from 1956 to 1960 this AEC Division has awarded grants of over 12½ million dollars for capital equipment. The reporting institutions have purchased nuclear equipment and facilities from their own funds which more than match the AEC grants to these institutions. In addition, the AEC has loaned source and special nuclear materials such as uranium, heavy water, etc., valued at over 10 million dollars to the 125 grantee institutions. The survey also provided partial information on grants awarded by other divisions of the AEC: the Office of Isotope Development and the Division of Biology and Medicine. However, no conclusions were drawn concerning grants from these divisions since the data were incomplete.

The educational value of the nuclear equipment grants awarded by the Division of Reactor Development of the AEC is indicated in part by the nuclear engineering and science laboratory course enrollments listed by the 79 reporting institutions. They reported 3489 student registrations in 183 nuclear laboratory courses during the 1959–60 academic year, an increase of 24.4% over the enrollment in 1958–59. Also the reports indicate that nearly 85% of the students were taught in laboratories which are completely or partially equipped as a result of AEC grant funds.

A projection of the equipment needs of the reporting schools shows that during the next 3 or 4 years, the engineering colleges now participating in the grants program will require over 20 million dollars of additional nuclear equipment. In addition there is considerable merit to the concept of improving, through a new grant program, the nuclear science capabilities of about 100 outstanding liberal arts and sciences colleges which could provide graduates of high caliber inter-

Presented at the Annual Meeting of the American Society for Engineering Education, Purdue University, June 20, 1960.

ested in further studies in the field of nuclear engineering and sciences.

The Committee expresses concern that the present budget level of the AEC Nuclear Equipment Grant Program (approximately two million dollars per year) is grossly inadequate for the important task ahead.

Introduction

In 1954 the revised U. S. Atomic Energy Act removed previous stringent security regulations and made available to the public considerable basic information and materials relating to nuclear fission. This made it possible for educational institutions to readily disseminate knowledge in the field of nuclear science and engineering provided that the teaching staff had adequate background training and proper facilities.

Most institutions of higher learning were immediately faced with a shortage of teachers in this field and practically no appropriate laboratory facilities existed on the campuses. A few trained professional personnel were employed by educational institutions from government and industrial AEC contractor sites to teach this relatively new field. Others who were experienced in nuclear matters and who were on the staffs of educational institutions were shifted to nuclear science and engineering teaching assignments. These teachers had gained such experience during and after World War II by means of full-time jobs, summer employment, or part-time consulting activities in the Atomic Energy program. However, all such sources of trained teaching personnel were capable of providing only a small fraction of the teachers needed in this educational activity. This was particularly true in engineering colleges throughout the nation, which were attempting to meet the educational needs for graduate nuclear engineers who could make effective contributions to the rapidly developing field of nuclear energy technology. Consequently, of necessity, a number of teachers of nuclear science and engineering were trained after 1954 by means of cooperative programs worked out with the Atomic Energy Commission. Some were given leaves of absence from their home institutions to work at an AEC national laboratory or on the site of an AEC contractor. Others were sent to more formal training activities such as the Oak Ridge Institute of Reactor Technology. Still others were trained at one or more Summer Institutes in Nuclear Science and Engineering which have been jointly sponsored by the AEC and the American Society for Engineering Education since 1956. The results and relative merits of these AEC–ASEE Summer Institutes are discussed in another paper in this series.

It was soon recognized that practically all of the teachers conducting programs in nuclear science and engineering in institutions of higher learning were seriously handicapped by the lack of proper laboratory equipment to provide the necessary demonstrations and student laboratory experiments. The Division of Reactor Development (DRD) of the AEC, recognizing these severe limitations in the educational processes, issued a policy statement in the summer of 1956 to the effect that over a period of years grant funds in amounts not to exceed a total of $350,000 per qualified school would be available for laboratory equipment needed to supplement the knowledge attained via classroom lecture courses. To quote from the original AEC policy statement: "The Commission has authority to assist non-profit educational institutions by making grants and contributions for acquisition of apparatus and equipment for educational and training activities. The following program of assistance is designed to assist universities to acquire the various items of equipment which are needed to present adequate and meaningful laboratory course work in nuclear energy technology." In the section related to assistance for training reactors, the policy states: "AEC financial assistance in the procurement of a training reactor will be given only to educational institutions with engineering curricula accredited by the Engineers' Council for Professional Development." The policy also states that support for a training reactor must be related to a "broad curriculum in nuclear energy technology at the graduate level. . . ."

It is interesting to note the repeated emphasis on nuclear energy technology and the specific reference to ECPD-accredited institutions in the case of assistance with procurement of a training reactor. This emphasizes the recognition of needs for laboratory facilities in the broad area of nuclear engineering as well as the nuclear sciences which underlie this technology.

Since 1956 assistance has been rendered, through the AEC Division of Reactor Development equipment grant program, to 125 colleges and universities in the United States in the amount of $12,741,917 as of January 1, 1960. Also during these years, a similar type of teaching equipment assistance program has been made available by the AEC Division of Biology and Medicine and the AEC Office of Isotopes Development provided that the laboratory courses requiring equipment were related to these areas of interest.

At its October 1959 meeting the ASEE Nuclear Committee decided to make a survey of those institutions who had received AEC–DRD equipment grants. The reporting and evaluation of the results of this survey are presented in the remainder of this paper.

The Survey and Methods of Evaluation

In December, 1959, questionnaires were sent by the American Society for Engineering Education to the deans of engineering of the institutions who had received Atomic Energy Commission Division of Reactor Development nuclear equipment grant funds. Also, questionnaires were sent to all institutions who had sent teachers to one or more AEC–ASEE Summer Institutes. In cases where institutions participated in both activities, a combined survey form was utilized. Otherwise, a single questionnaire was used for the appropriate activity. Survey forms were completed and returned by 79 institutions who had received equipment grant funds from various divisions of the AEC. Of these 79 returns, a total of 77 had received Division of Reactor Development grants, 12 had received grants from the Office of Isotope Development of which 11 had also received DRD grants, and 9 had received grants from the Division of Biology and Medicine, of which 8 had also received DRD grants. It should be pointed out that no attempt was made in this survey to obtain complete information concerning AEC grants from the Office of Isotope Development or the Division of Biology and Medicine. The data returned by the deans of engineering concerning such grants have been tabulated, but no extensive analysis or projections are based on these data because information is incomplete.

Data were collected and reported on the following phases of the grants program:

1. Total grants received by the reporting institutions including a brief description of equipment obtained and the AEC source of grant funds.

2. Grants which had been requested but not yet received by the reporting institutions.

3. Type and estimated cost of additional equipment required which represents the minimum needs to effectively operate the program for the next three or four years (regardless of source of funds).

4. Self-support provided by the reporting institution as to square feet of laboratory space, expenditures for capital equipment and facilities, annual operating costs, and annual salary costs.

5. Nuclear materials loaned to the institution by AEC. Reported information includes use of materials on loan, both for laboratory programs which are partially supported by AEC equipment grants and for laboratory programs which are completely supported by institutions' equipment purchases.

6. A tabulation of nuclear engineering (or applied nuclear science) laboratory courses established and enrollments in such laboratory courses for the academic years 1958–59 and 1959–60. A three-way division of this information was requested: (a) laboratory courses entirely supported by AEC equipment grants; (b) laboratory coures jointly supported by AEC and the institution's equipment funds; and (c) courses supported entirely from institution funds.

7. General comments by the reporting institutions concerning the value of the AEC equipment grants in establishing, expanding, and improving the nuclear program of those institutions. Comments were also requested as to overall appraisals of all AEC assistance including the Summer Institute programs.

In addition to the above data, which are reported in Tables 1 through 6, the committee obtained information from the AEC Division of Reactor Development on their total grant program to 125 institutions as well as the availability of research reactors, teaching reactors, and subcritical assemblies on university campuses. Table 7 reports these data and Table 8 represents a comparison of the ASEE survey results with the total grants awarded by AEC–DRD. An evaluation of statistical information obtained from the survey and the conclusions and recommendations follow the presentation of the Tables.

Discussion of Survey Results

Number of Institutions Reporting

Seventy-nine institutions reported information concerning AEC equipment grants (Table 1). Of these, 72 were institutions with engineering curricula accredited by the Engineers' Council for Professional Development (ECPD). The remaining seven were non-accredited schools. Seventy-six institutions were completely in favor of the grants program and indicated that considerable assistance was derived from the equipment. Three additional institutions were in favor of the grants, but suggested certain changes in grant policy or administration. For example, one institution indicated that equipment grant funds should provide for graduate student research equipment, as well as equipment primarily for formal laboratory course work. No reporting institution was opposed to the AEC grants program nor indicated any undesirable results from its implementation.

TABLE 1

EVALUATION OF AEC EQUIPMENT GRANTS PROGRAM

Institutions Reporting Grants Received	79
ECPD Accredited Institutions Reporting	72
Non-Accredited Institutions Reporting	7
Completely in Favor of Grants	76
Institutions in Favor But Suggest Administrative Changes	3
Institutions Opposed to Grants	0

Grants Received by Reporting Institutions

The total of AEC grants reported by the 79 institutions was $9,406,876 or an average of approximately $119,000 per institution (Table 2). Of this amount, $430,829, or approximately 4.5% of the reported AEC grant funds, was awarded by AEC Office of Isotope Development or AEC Division of Biology and Medicine. As previously stated, no definite attempt was made to obtain complete information concerning grants made by these AEC Divisions. Furthermore, one would not expect a large proportion of grant funds from these sources to be reported by engineering schools in view of the following two facts: (a) the DBM program was not designed primarily to aid engineering and physical science, but rather to emphasize the biological and medical areas of education; and (b) the OID program was started about 2½ years later than that of DRD and had less total

TABLE 2

GRANTS RECEIVED BY REPORTING INSTITUTIONS

AEC Source of Grant	Grants Received	Total Grant Funds Reported	Average Grant	Average for 79 Institutions
Div. of Reactor Development	77	$8,976,047	$116,500	$113,600
Office of Isotope Development	12	290,583	24,100	3,650
Div. of Biology and Medicine	9	140,246	15,500	1,750
All AEC Sources	79	9,406,876	119,000	119,000

TABLE 3

GRANTS REQUESTED BY REPORTING INSTITUTIONS
(NOT YET RECEIVED)

AEC Source of Grant	Grants Requested	Total Grant Funds Requested	Average Request	Average for 79 Institutions
Div. of Reactor Development	37	$2,920,248	$79,000	$37,000
Office of Isotope Development	4	199,344	48,400	2,500
Div. of Biology and Medicine	2	32,419	16,200	400
All AEC Sources	43	3,152,011	73,300	39,900

funds available for support of equipment needs concerning radioisotope technology.

It is of interest that of the 77 DRD grants reported only five are in excess of $300,000 while 42, or 54.5%, are less than $100,000. Additional comparison of these 77 grantee institutions with the total 125 institutions which have received DRD grants is contained in Table 8.

Grants Requested by Reporting Institutions (not yet received)

Forty-three institutions reported pending grant requests to all AEC grant sources for a total of $3,152,011 or an average request of $73,300 (Table 3). When divided among the 79 reporting institutions, this amount averages $39,900 per institution. Again, the total grant funds requested from OID and DBM sources constitute a small percentage of the funds requested by the reporting institutions. It is of interest to note that the grant requests now under consideration equal about one-third of the grant funds awarded since 1956.

Additional Equipment Needs of Reporting Institutions

Sixty (60) institutions reported additional equipment needs of $11,593,447 or an average for 79 institutions of $147,000 (Table 4). These needs are in addition to funds already requested, but not yet received. When one adds to this the value of the grants requested, the total additional needs of the 79 reporting institutions amount to $14,745,458, or $186,900 per institution. The survey questionnaire specifically asked for additional needs over the next three or four years, so the tabulated information does not represent a complete statement of long-range needs and anticipated expenditures regardless of source. Further, the small percentage of "grants requested" to "total additional needs" (21.4%) would indicate that engineering colleges are not formalizing their future needs into grant proposals to the extent that might be expected. The current level of the DRD grant program at about two million dollars per year might account, in part, for this situation.

Self-Support of Programs by Reporting Institutions

Virtually all of the 79 reporting institutions have provided self-support for their nuclear program in one or more respects (Table 5). The questionnaire re-

TABLE 4

ADDITIONAL EQUIPMENT NEEDS OF REPORTING INSTITUTIONS

Equipment Needs	Institutions Reporting	Total Required	Average Required	Average for 79 Institutions
Future Needs Not Including AEC Grants Requested	60	$11,593,447	$193,000	$147,000
AEC Grants Requested (Not Yet Received)	43	3,152,011	73,300	39,900
Total Additional Needs	69	14,745,458	214,000	186,900

TABLE 5

SELF-SUPPORT OF PROGRAMS BY REPORTING INSTITUTIONS

Support Item	Total Reported	Average for 79 Institutions
Laboratory Space Square Feet	380,212	4,800
Capital Equipment and Facilities—Dollars	$10,796,230	$136,500
Annual Operating Expense—Dollars	$ 610,666	$ 7,730
Annual Salaries—Dollars	$ 1,786,273	$ 22,600

quested information on: (a) laboratory space; (b) capital equipment and facilities; (c) annual operating expense; and (d) annual salaries expense. The space provided for nuclear programs totaled 380,212 square feet. Expenditures for capital equipment and facilities from the institutions' own funds amounted to $10,796,230. It should be noted that this investment exceeds the capital equipment grant funds from all AEC sources reported. Furthermore, these institutions are budgeting institutional funds of $2,396,939 on an annual recurring basis for operating expense and salaries. Obviously, this recurring contribution will continue and increase as the programs expand in future years. This represents good evidence of the seriousness and intent of the institutions concerned.

Laboratory Class Enrollment Reported

Survey results provided further supporting evidence of the value of the AEC equipment grants as well as the growing nature of the program and the serious intent of the institutions offering educational programs in nuclear engineering and science. In 1959–60 the 79 reporting institutions listed 183 laboratory courses and student enrollments of 3489 in those courses (Table 6). This represents a 22.1% increase in courses and a 24.4% increase in enrollments over the previous year, 1958–59. When one considers that only a very few laboratory courses existed in engineering schools prior to 1956, this is truly a remarkable growth pattern. Also in 1959–60, 84.8% of all laboratory student enrollments were taught in laboratories where the nuclear equipment was completely or partially furnished through AEC equipment grant funds. A projection of these data to the 125 schools who have received DRD grants would indicate that laboratory student enrollments were well in excess of 5,000 during 1959–60.

While no separate tabular summary of loans or grants of AEC source and special nuclear material is presented in this paper, the questionnaires show that many different types of materials were received by the institutions and that they were utilized with the laboratory courses in much the same ratio as indicated in this

TABLE 6

LABORATORY CLASS ENROLLMENT REPORTED

Source of Equipment Used	Academic Year	Number Courses	Number Students	Per Cent of Total Enrollment
AEC Grant Equipment	1958–59	46	436	15.6%
	1959–60	65	681	19.5
Institution Plus AEC Equipment	1958–59	83	1901	67.8
	1959–60	100	2280	65.3
Institution Equipment	1958–59	21	466	16.6
	1959–60	18	528	15.2
Total Regardless of Source	1958–59	150	2803	100
	1959–60	183	3489	100
Percent Increase Over 1958–59	1958–59	—	—	
	1959–60	22.1%	24.4%	

Table in regard to source of equipment from AEC funds or institution's funds.

A Review of AEC–DRD Equipment Grants

Data on the 125 institutions which have received nuclear grants from AEC's Division of Reactor Development are presented in Table 7. This table also indicates the relative amount of grant funds received by various institutions, whether or not they are ECPD accredited, and how many have research reactors, training reactors, or subcritical assemblies. The data were obtained from AEC and include all grants made by DRD through the 6th grant series, December, 1959. They are, therefore, comparable from a time standpoint with the ASEE questionnaire. Of the 125 schools, 104 are ECPD accredited and 21 are not accredited by that organization. Fifty-eight schools (46.4%) received grants of less than $50,000 and eight (6.4%) received grants over $300,000. The average grant for the 125 schools was $102,000—slightly lower than that reported by the 79 institutions for this survey. Of this group of 125 grantees, 8 have research reactors, 31 have teaching reactors, and 88 have no reactors on their campuses. Also 81 have subcritical assemblies, 20 have both subcriticals and reactors, 44 have no subcriticals and 28 have neither subcriticals nor reactors.

Comparison of ASEE Survey with Total DRD Grants

It is of interest to compare the data obtained from the ASEE survey with that of the AEC and to attempt to project the reported needs of the 77 institutions to embrace the 125 institutions who have received DRD nuclear equipment grants. There are at least two methods of projection which could be introduced. One of these would be a projection on the basis of the ratio of schools reporting to the total. The other method would be on the ratio of the amount of grants reported to the total grants awarded by DRD. Both methods of projection are illustrated in Table 8 for the reported total additional needs previously shown in Table 4. Thus on a "ratio of number of institutions" basis the projected total additional needs would be $23,740,200 while on a "ratio of grants reported" basis these projected needs would be $20,791,000.

Another method of viewing the projected total needs would be to evaluate the funds necessary to put all of the 125

TABLE 7

AEC—DIVISION OF REACTOR DEVELOPMENT TABULATION OF GRANT AMOUNT WITH RESEARCH RESEARCH REACTORS, TEACHING REACTORS, OR SUBCRITICAL ASSEMBLIES ON CAMPUSES*

Item	Amount of Grant, Thousands of Dollars							
	1–49	50–99	100–149	150–199	200–249	250–299	300–350	Total
Institutions	58	18	14	14	10	3	8	125**
Per Cent of Total	46.4%	14.6%	11.2%	11.2%	8.0%	2.4%	6.4%	100%
ECPD Accredited	39	17	14	14	10	3	7	104
Non-Accredited	19	1	—	—	—	—	1	21
Research Reactors	1	—	2	1	2	1	1	8
Teaching Reactors	1	1	4	11	6	2	6	31
No Reactors	57	16	8	3	2	—	2	88
Subcriticals	31	16	9	6	9	2	8	81
Subcritical and Reactor	1	—	1	3	7	2	6	20
No Subcritical	27	2	5	8	1	1	—	44
Neither Subcritical nor Reactor	27	1	—	—	—	—	—	28

* Information obtained from AEC. Equipment listed was not necessarily purchased from DRD grant funds.

** Total grants for 125 Institutions = $12,741,917 through December, 1959.

TABLE 8

COMPARISON OF ASEE SURVEY WITH DIVISION OF REACTOR DEVELOPMENT EQUIPMENT GRANTS AWARDED THROUGH DECEMBER 1959

Reporting Source	Number Institutions	Total Amount	Average Amount
Div. Reactor Development Total Grants Awarded	125	$12,741,917	$102,000
ASEE Survey Report of Div. Reactor Development Grants	77	8,976,047	116,500
Ratio of Total to ASEE Report	1.61	1.41	

Estimated Future Equipment Needs Based on Ratio of Institutions: $1.61 \times 14{,}745{,}458 = \$23{,}740{,}200$
Estimated Future Equipment Needs Based on Ratio of Grants Reported: $1.41 \times 14{,}745{,}458 = \$20{,}791{,}000$

institutions up to their maximum grant ceiling of $350,000. This would require additional grant funds in excess of $30,000,000. It is felt that additional grant funds of approximately $20,000,000 would be an appropriate projection of future needs and requests for the AEC nuclear equipment grants provided under the policy and administration of the Division of Reactor Development. A further check of the validity of such projections is the projection of grants currently requested from AEC from Table 3 to 125 institutions. Such a projection gives a total of $4,800,000, compared to the present $5,000,000 of grant requests now being reviewed by AEC.

Conclusions and Recommendations

There is every indication from the results of this survey that the AEC nuclear equipment grant program has been extremely successful. These grant funds have provided engineering colleges with an important portion of the laboratory equipment necessary to activate proper educational programs in nuclear engineering and sciences in these institutions. The grants program has been effectively administered by personnel of the AEC Division of Reactor Development, Education and Training Branch.

There has been a worth-while interrelationship between the AEC nuclear equipment grants program and the AEC–ASEE Summer Institute program. There is evidence that in many cases, the faculty members attending the summer institutes have been responsiblbe for the specification and use of nuclear laboratory equipment on their home campuses and that much of this equipment has been provided through AEC grants. Also, since the proposals for grant funds must stipulate the type of experiments, etc., there is little doubt that a number of institutions sent faculty members to Summer Institutes in anticipation of submitting grant proposals.

A further significant fact is that no institution opposed the grant program and only three institutions had minor comments on the administrative policy of the grant program. The extent of self-support of the reporting institutions which more than equalled the value of the AEC grants in capital equipment and facilities alone is important evidence of the serious intent of the grantee institutions. The dynamic growth of this relatively new field of instruction, in spite of the shortage of teachers, the high cost and special nature of required equipment, and the advanced level of instruction, indicates the capability and willingness of engineering colleges to introduce new and important subject matter into their curricula.

It is important to note that the projected needs of engineering colleges over the next three or four years are in excess of $20,000,000 and that the requests now pending in the form of proposals to AEC are about $5,000,000. The committee expresses its concern that the present budget level of the AEC nuclear equipment grant program is only about $2,000,000 per year. Results of this survey would indicate that a substantially higher level of operation would be ap-

propriate, at least for the next several years when many institutions will be bringing their nuclear programs into full productivity.

Also as has been previously explained, the principal recipients of DRD grants to date have been institutions with engineering programs in nuclear energy technology. In keeping with the educational pattern of our time, it would be logical and helpful, in many respects, if a program of support were initiated to assist a number of colleges of liberal arts and sciences of high standing which regularly graduate a substantial number of students who then proceed to take graduate work in engineering and the physical sciences. Such assistance would provide suitable equipment for the improvement of course offerings in atomic and nuclear physics, as well as physical chemistry and perhaps radio chemistry in these colleges. While it is difficult to predict the number of liberal arts and sciences colleges who would benefit from such assistance, a grant program of approximately $10,000,000 averaged over about 100 such colleges would seem to be an appropriate estimate of the needs.

In general, the survey has satisfactorily fulfilled the requirements of the evaluation committee for information and opinions from grantee institutions. Therefore, we wish to record our appreciation for the fine cooperation of the engineering schools who participated in this survey and to Leighton Collins, Secretary of the ASEE, for invaluable aid in the preparation and distribution of the questionnaires.

GUGGENHEIM FELLOWSHIPS FOR ROCKET AND SPACE FLIGHT STUDIES

Graduate fellowships up to $2,000 plus tuition for study in 1961 are being made available by the Guggenheim Foundation for the field of rockets, space flight, and flight structures. The fellowships are open to students with bachelor's degrees in aerodynamics, fluid mechanics, physics, physical chemistry, applied physics, applied mathematics, engineering sciences, aeronautical, mechanical, chemical, or civil engineering. The fellowships are for study at Princeton and Columbia Universities and the California Institute of Technology.

Applications must be received by March 1, 1961. Applications and descriptive booklets are available from deans and directly from The Daniel and Florence Guggenheim Foundation, 120 Broadway, New York 5, New York.

NSF GRADUATE LAB DEVELOPMENT

The National Science Foundation announces that March 1, 1961 is the next closing date for receipt of proposals in the Graduate Laboratory Development Program. Proposals received after March 1 will be reviewed following the next closing date, September 1, 1961. This program requires at least 50 per cent participation by the institution with funds derived from non-Federal sources.

Purpose of the grants is to aid institutions of higher education in modernizing, renovating, or expanding graduate-level basic research laboratories used by staff members and graduate students. Only those departments having an on-going graduate training program leading to the doctoral degree in science at the time of proposal submission are eligible at present.

Proposals, as well as requests for additional information, should be addressed to: Office of Institutional Programs, National Science Foundation, Washington 25, D. C.

Understanding the Learning Process

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Most of the learning principles which the psychologist suggests as being relevant to college teaching are not greatly different from our ordinary conceptions of good teaching. Nevertheless, the college teacher often forgets them when he is designing his college course, and a review may therefore be worthwhile.

I suppose one of the most familiar principles of learning is the principle that if we expect students to learn and to apply what they're learning to new situations, they have to practice. But practice does not make perfect. Practice works when the learner knows the results of his practice.

Several years ago we ran an experiment comparing the effectiveness of three methods of teaching our elementary psychology course. One of the methods was what we called recitation drill. A second method was discussion. The third method was independent study. The results of this experiment were contrary to our expectations. Not only did the tough recitation-drill method produce the best results on the final examination of the course, but the students liked it and more of these recitation students took advanced courses in psychology. In terms of our principle of feedback or knowledge of results, these students had been quizzed frequently, and they got the results. Consequently, they learned the basic facts and principles which were covered on the examination. There may be some question about whether these are the only objectives we want in a course, but it does illustrate the fact that if you have an objective, and if you give students the knowledge of how they're progressing towards this particular objective, they're going to achieve the objective the best way they can.

I hope, however, that this won't lead you to dismiss the discussion technique. The following year we ran another experiment in which we gave the students a great deal of power to make decisions for the class as a whole. The experimental classes made decisions about how many tests they'd have during the term, what kind of tests they'd have, when they'd have them, and what assignments they'd have. These decisions made in our experimental groups were then simply imposed by the instructor upon the corresponding control sections. In this experiment our students didn't differ in performance on the final examination. But the classes did differ in their ability to apply their knowledge to the analysis of behavior presented in a film. This illustrates again that our classes learn what they practice with knowledge of results. The students in our experimental course had had experience in applying what they learned during class discussion and had their ideas tested against those of other students and the instructor. If our goal is application, or critical thinking,

Learning to teach and, in the larger sense, becoming an engineering educator, are processes about which we really know very little. They continually take place, they are very important, and they will soon become urgent. After much thoughtful study, the Committee on the Development of Engineering Faculties of ASEE organized the Cleveland Conference of 19–21 November, 1959, to bring together a small group who could identify and assemble the resources in our own and other fields, including formal education, that can best aid this process of learning to become a teacher and educator. This paper is one of the series originating from that Cleveland Conference.

we need to provide opportunities for students to practice and to get results of practice of those particular skills.

Let me digress for a minute to point out that these principles of learning which our graduate students can utilize in their teaching, are also principles which are relevant for us in training teachers of engineering or any other subject. Presumably if we want someone to learn how to teach, one of the important things in the learning situation should be an opportunity to get feedback, and I suspect that one of the most important parts of internship type experience is helping the interns get some feedback on how they're doing. Part of this can be done by observation and by student ratings, but part of what we have to do in training graduate students or teacher interns is to help the teacher learn to get his own feedback from his group. This means helping him become sensitive to gestural and facial reactions, develop skills in eliciting participation, and learn to use written products such as examinations as cues to his effective and ineffective teaching.

The second prinoiple of learning relevant to college teaching is contiguity. This means that the closer the feedback to the action which is being learned, the more effective the feedback is. At one time in marksmanship training the armed forces followed the practice of having each marksman fire several shots at the target, then having the target brought back so that he could examine the pattern of shots which he fired. When knowledge of results was provided after each shot, instead of after several, training time in marksmanship was reduced. The one big advantage of the teaching machine is that it does provide immediate feedback to the learner.

Marksmanship training also illustrates another principle. Since soldiers rarely sight and fire in combat as they have in training, the training was not efficient for developing combat marksmanship. Similarly, we may be able to set up teaching procedures which are very effective as far as getting our students to learn to pass the final examination in the course but which are relatively ineffective in helping our students achieve other long term objectives. In a recent study we gave two kinds of examination, one, an objective examination, the other, an essay test which was designed to measure critical thinking about the material. We could identify teachers whose students did better on the objective examination than would have been expected from aptitude measures. We also found that we could identify effective and ineffective teachers as defined by student performance on the essay examination. But the teachers who were most effective as measured by their students' performance on the objective examinations, tended to be those who were less effective than the others as measured by the student's performance on the essay examinations. In other words, we could identify two kinds of effective teachers, one, a teacher who is effective as measured by achievement on the objective examination, the other, a teacher who is effective as measured by his student's achievement on essay examinations. Once again this points to the fact that when we talk about effective teaching, we have to specify fairly carefully what our objectives are.

A third principle of learning which is relevant to teaching is the principle of activity. There seems to be a good deal of evidence that other things being equal, the learner who is active will learn more readily or at least remember longer than the learner who is passive. During World War II the Navy trained people to recognize airplane silhouettes presented rapidly. In one form of training the instructor identified each silhouette as it was flashed; in the other method, the trainees were asked to guess the name of the plane before the instructor identified it. Active learning, where the students actually had to make a response, proved to be much more effective than passive learning. This has obvious implications for the issue of lecture versus discussion. It also has implications for training teachers. Training should be more effective if your graduate students have a chance to actively try out things and to participate, than if they just listen to lectures about the psychology of learning and other aspects of teaching.

A fourth learning principle is organization. In looking across a number of modalities, it appears that the information capacity of the human for unrelated bits of information presented simultaneously may be six to eight. For instance, if I read a group of random numbers and ask you to repeat them you'll find that you can repeat groups of five or six but if I read groups of ten you'll be able to remember only four or five. Psychologists early discovered that it wasn't just the amount of information here which made the difference, but the organization of the information. If instead of six syllables, for example, I give you words, you'll be able to remember more syllables. If instead of words, I give you a sentence, you can remember a great many more words. If I give you some sort of meaningful sequence, like 2 4 6 8 10 12, etc., you can repeat as many as I give. By organizing information into chunks, by providing a framework through which information can be integrated, the capacity of the human becomes vastly greater. When we present unrelated information (or information which may be related in the mind of the instructor, but not in the mind of the student) we get something like the dazzle that occurs when you get too much light flashed into the eye. If students do not have a way of organizing information, we need to select very carefully the things that we want them to know so as not to clutter up the situation with excess information which may interfere with the recall of the minimum essentials.

I suppose the fundamental problem in teaching is how to get application, or transfer. Generally, you get better transfer when there's been some variability in training. If you give students many examples or if they build up a principle from a number of different facts there is a much better chance that they'll be able to transfer their learning to new situations than if their learning has been with a specific example or has been laid out for them by the instructor. We also know that in general the more closely your teaching is related to what it is you want it to be used for, the better chance that it will be applied. If you want applications to specific kinds of situations it is simply good sense to give examples from these situations of how the material applies, or better yet, to give the students practice in making this kind of application. In most situations it also helps to verbalize the principle involved.

To some extent transfer is more likely to occur when motivation isn't too high or isn't too low. If motivation is too low, the learner apparently doesn't bother to try to see how he can use his information. If motivation is too high, students stick to a very narrow range of possibilities, failing to try new approaches.

We have already referred to the importance of motivation in learning and transfer. Let me briefly review a few points about motivation. Modern motivation theory is placing much more emphasis than formerly upon the pleasure involved in exploring and in new experiences. This suggests that in teaching we may be able to rely upon students learning things simply because learning in itself is pleasurable.

Psychologists are also still interested in anxiety and we are also learning more about it. The results of recent experiments indicate that if we increase anxiety, we get improvement in performance up to a point. As we continue increasing anxiety, we reach a point where further increase in anxiety results in a decrement in performance. Many of our students in the ordinary classroom examination are so anxious that they fail to perform as well as they should on the basis of what they are able to show in less stressful situations. If we reduced anxiety, we could get better performance from these students. Unfortunately, whatever we do affects some students positively and some students negatively, for some students are probably not motivated enough.

The group norms in a class and in a college have much to do with the students' response to our attempts to motivate them, and this also applies to training teaching fellows. The success of our program in psychology at Michigan has been largely due to the amount of group spirit which we get among the graduate students who are in the program. Be-

cause we think teaching is important, because we set up the situation where the teaching fellows come together a couple of times a week to talk about their teaching, because we have their offices together, the teaching fellows are continuously in contact with other people who are concerned about teaching. This is a situation which tends to reward interest in teaching. This group pressure which teaching fellows exert upon one another is probably one of the most important things in their learning how to teach more effectively.

The Thesis Abstract, Fruit of Neglect

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In these days of ever-increasing publication of technical information, the importance of the abstract as a means of informing management and as a tool by which the scientist and the engineer keep abreast of their fields needs no underlining. Everyone admits it. It is fair, then, to ask whether our students are being properly trained to write an abstract that will do the job it is expected to do. How are they trained, and how effectively?

Most student engineers and scientists must take a technical report writing course sometime—usually early—in their college program. The course normally involves the preparation of a "long technical report," with an abstract. The artificial nature of most such reports is obvious: the student is immature, his work is derivative, and the abstract is an academic exercise which will be read by one person, well known to the student. Under the circumstances these conditions are hard to avoid, but they are clearly not much like those surrounding the preparation of a published report or article and its abstract.

In the educational world it is assumed, however, that the student will retain the principles he has learned in the classroom and applied in the academic exercises of his undergraduate courses. The simplified textbook problems in mathematics and statics and chemistry will find their analogs in his advanced and graduate courses and in the "real" problems which must be solved when he is out of school.

Indeed, a good part of what he has learned is put to practical test while he is still in school. His design courses and his thesis course are in the curriculum for just that purpose: to cause him to synthesize and apply his newly gained knowledge. But when is his knowledge of abstract-writing tested? When does he make practical application of the principles he has been taught in English 123?

For most students, this test, too, comes when they write their senior or master's thesis—theoretically, at least. The thesis contains the only real abstract the student writes during all his college years; when he writes it, he has matured somewhat in age and knowledge since his report-writing course, his work is at least partly original, and his writing must be read by several persons, some of them subject-matter specialists and some of them not. Unfortunately, however, although the thesis proper is carefully and critically read, the abstract of it may receive less attention than does the form of the title page.

Is there any basis for this indictment? Any educator concerned with the quality of his students' writing can answer this question to his own satisfaction by evaluating the abstracts of this year's or last year's theses. There is one difficulty in this procedure, however: to evaluate an

abstract properly requires at least cursory comparison of the abstract with the thesis body, as well as some familiarity with the terminology and concepts involved; that is, considerable time is required and some technical training is useful if a general sampling of theses is to be examined.

Because of this difficulty, it is unlikely that many such evaluations have been made, and so the results of a study here at the Institute of Technology may be of interest. By way of additional information, it might be noted that every graduate engineering student at the Institute must take three or four quarter hours of "technical English" regardless of his background. Since two of these hours represent a course offered in the student's penultimate quarter, a course closely related to the preparation of his thesis, it has been assumed that the student was especially well prepared to write a good thesis abstract. The validity of this assumption has now been tested.

In the fall of 1959, a graduate student in aeronautical engineering, Major Robert J. Wilson, USAF, wanted to do a special study in English to absolve part of the four hours he was required to take. An evaluation of thesis abstracts was among the topics suggested to him, and what follows is a brief description of his work.*

He began by consulting various published statements about abstracts to derive a set of generally accepted standards by which to evaluate a thesis abstract. These standards are familiar to most of us: the principal ones concern content, style, length, and proportion, or emphasis.

With a checklist of the standards drawn up, Major Wilson then evaluated 63 recent master's theses in aeronautical and electrical engineering. His preparatory study and his technical education qualified him to render reasonable judgments based on application of the check list standards and comparison between abstract and thesis proper.

His most important finding was that the abstracts were incomplete. If as a minimum standard it is accepted that the abstract should state the purpose of the investigation, the method, the results, and the conclusions, then more than half of the 63 were incomplete. An additional sentence or two would have completed many of them, but 33% contained no description of method, and a shocking 25% said nothing at all about results, conclusions, or recommendations. Obviously, an abstract lacking these pieces of information is worthless.

What these figures say about our instruction in English and our reading of theses is disconcerting. We are taking action to change our practices. But the thought that other schools may have lapsed into complacence similar to that we felt not long ago prompts this brief note and the hope that it will stir others to do more than pay lip service to the growing importance of the abstract.

One more thing needs to be said: English teachers, like mathematics teachers and physics teachers and others, rely on the engineering teachers to reinforce and supplement their teaching; an engineering teacher checks his students' mathematics as a matter of course. So should he check his students' English. And particularly in reading a thesis, the student's most important piece of writing, the engineering teacher should give the presentation the same attention and criticism that he would accord to a colleague's manuscript of a book or an article. The student deserves no less.

* Major Wilson's permission to report his results is gratefully acknowledged.

PH.D. PROGRAM AT CLARKSON

In September, 1961, Clarkson College of Technology will initiate graduate programs at the doctoral level.

Dr. William G. Van Note, president of Clarkson, has announced that under the first two new programs, the Chemical Engineering and Chemistry Departments will offer graduate work leading to the doctor of philosophy degree. He said that later the Physics Department and some of the other engineering departments will expand their graduate programs to offer work leading to the Ph.D. degree.

Follow-up Survey of Enrollments and Staff in Various Patterns of Graduate Study

from 58 Responding Institutions for the Years '48–'52–'56–'57–'59

CORNELIUS WANDMACHER

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Graduate student enrollments in engineering continue to soar. For the 58 representative institutions reporting in this survey, most significant gains during the last three years ('56–'59) were made in the area of full-time graduate students (up 45%) and the area of part-time students employed on-campus by universities in research or teaching (up 88%). The aggregate of these two groups who spend full-time on campus in study, research, and/or teaching shows an overall increase of 60% since '56.

At the same time enrollment of part-time graduate students, employed off-campus in engineering practice, continues to rise (up 27%), but at a decreasing rate.

Complete breakdowns by institutions are given on the attached pages. It should be noted that these statistics *do not include* all institutions offering graduate study under various patterns. The basic group of 58 institutions reported were those which responded to the original (1956) survey of "Patterns of Graduate Study" and the first follow-up in 1957, or which since have sent in statistics. Enrollment statistics for all institutions may be found in the U. S. Office of Education reports, a summary of which is published in the Yearbook-Directory Issue of the JOURNAL OF ENGINEERING EDUCATION (February 15).

In this survey the number of full-time and university-employed graduate students (13,300) is still substantially less than the number of part-time off-campus employed graduate students (17,700). However, the gap is steadily being closed. Not since the 1948 period has the number of full-time and university-employed graduate students (then 6,400) exceeded the number of graduate students employed off-campus (then 5,300). But many universities are now reporting university-associated student enrollments well above the "veteran"-stimulated levels of 1948.

In a number of instances off-campus offerings of part-time graduate study have been terminated. Although there are a few instances of off-campus graduate study centers recently opened or presently planned, the trend in this direction seems to have subsided.

Two institutions report growth in co-op (intermittent) graduate enrollment but the numbers of such students are still quite small compared to those on other plans.

It might be concluded that the sharp increase in part-time graduate study experienced in the early 50's has satisfied an important need in the evolution of engineering education, but that the years immediately ahead may find the greatest growth in full-time and university-employed graduate student enrollment.

One of the distinguishing points of this survey has been the endeavor to seek out the actual numbers of graduate students who are university based by being either full-time students or by being part-time students with university-related employment in teaching or research. This segment of the graduate student population (Group I, II a & b in the tables) may be considered to be studying under a "geographic full-time" system. It may be that this distinction is much more important than those usually made between day and evening students or between full-time and part-time students as such.

Statistics concerning graduate faculty have not been totaled but allowed to remain in the tables by institutions. The identification of "graduate" faculty is a difficult task and the numbers indicated in many cases do not seem significant enough to be entered into totals. The comparison of number of full-time staff and adjunct staff teaching in graduate areas may, however, be significant by institutions.

As a final synopsis a listing of the "Principal Enrollments and Degrees Granted—1959" was prepared and the number of degrees granted included, assuming that such may be taken as an indicator of "productivity." This listing of institutions is more complete than the main table since it includes a number of institutions with substantial graduate enrollments which for one reason or another were not reported in the original survey of "Patterns of Graduate Study."

This '59 synopsis includes only institutions having either substantial full-time or substantial part-time enrollments, or both. While these 54 institutions represent only 34% of the 156 ECPD-accredited institutions, they did grant 91% of the doctor's degrees and 84% of the master's degrees in '59.

This type of listing undoubtedly omits certain institutions where work of outstanding quality is being done. Also inclusion of an institution in the list is indeed no guarantee that high quality work is being done.

But this '59 synopsis does indicate some of the challenges faced by the Graduate Studies Division and ASEE in the years ahead. For instance, nearly half of the institutions with "principal" enrollments in '59 still granted 5 or less doctor's degrees in that year.

While statistics never tell the whole story it is hoped that these numbers may nevertheless be helpful in weighing the problems before us.

Key:

I. Full-time Graduate Students enrolled in 12 or more credit hours per week of Graduate Courses or Thesis. Employment, if any, is only incidental.

II. (a) Part-time students—University employed in teaching.
(b) Part-time students—University employed in research.
(c) Part-time students in courses on campus. Employed off-campus.
(d) Part-time students at off-campus University study centers. Employed off-campus.
(e) Part-time students in courses at off-campus locations other than at University study centers. Employed off-campus.

III. Cooperative Graduate Students—Alternating full-time work and full-time study in intermittent periods.

IV. (f) Full-time Staff—Number of graduate faculty employed by University primarily as teachers. Give average number of faculty per year teaching in Graduate Courses, or advising thesis students.
(g) Part-time Staff—Adjunct graduate faculty employed primarily in engineering practice or research.

SUMMARY OF FALL SEMESTER ENROLLMENTS

Year	I. Full Time	II. Part-time Grad. Students					V. Total I + II + III
		Univ. Employed		Industry, Govt., etc. Employed			
		(a)	(b)	(c)	(d)	(e)	
1948	4,100	1,234	1,053	4,607	546	110	11,692
1952	3,519	1,032	1,297	8,456	891	917	16,386
1956	4,881	1,498	1,794	10,123	1,927	1,822	21,980
1957	—	—	—	—	—	—	—
1959	7,064	2,274	3,931	12,996	3,088	1,608	30,063

Follow-up Survey of Enrollments and Staff in Various Patterns of Graduate Study

Fall Semester Enrollment

Institution	Year	I. Full Time	II. Part-time Grad. Students					III. Co-op	IV. Graduate Faculty		V. Total I + II + III
			Univ. Employed		Ind., Govt. etc., Employed				Full Time	Part Time	
			(a)	(b)	(c)	(d)	(e)		(f)	(g)	
Akron, U.	1948	—	—	—	—	—	—	—	—	—	—
	1952	—	—	—	—	—	—	—	—	—	—
	1956	—	—	—	52	—	—	—	5	—	52
	1957	—	2	—	68	—	—	—	8	—	70
	1959	—	2	—	87	—	—	—	8	1	89
Arizona, U.	1948	14	—	—	—	—	—	—	3	—	14
	1952	14	—	—	—	—	56	—	3½	6	70
	1956	85	11	6	30	—	125	—	8	10	257
	1957										
	1959	169	28	20	57	—	—	—	36	1	274
Arkansas, U.	1948	—	—	—	—	—	—	—	5	—	—
	1952	5	3	3	1	15	—	—	20	—	27
	1956	10	4	4	2	—	—	—	25	—	20
	1957	20	4	3	—	8	—	—	29	—	35
	1959	25	6	3	—	33	—	—	36	—	67
California, U. (Berkeley)	1948	154	31	52	18	—	—	—	54	—	255
	1952	129	26	44	15	—	—	—	46	—	214
	1956	204	44	74	25	15	—	—	77	2	362
	1957										
	1959	206*	109	189	76	11	—	—			591
U. C. L. A.	1948	11	27	18	11	12	—	—	—	—	79
	1952	17	22	29	125	43	—	—	—	—	236
	1956	23	18	46	369	30	16	—	—	—	502
	1957	32	20	27	432	110	—	—	48	—	628
	1959	55	34	41	558	144	—	—	68	—	832
Carnegie Tech.	1948	79	21	—	70	—	—	—	41	1	170
	1952	79	17	—	92	—	—	—	42	2	188
	1956	93	15	—	86	—	—	—	49	3	194
	1957	138	12	—	220	—	—	—	60	1	370
	1959	176	8	—	195	—	—	—	65	2	379
Catholic U.	1948	2	—	—	28	—	—	—	2	2	30
	1952	7	—	—	76	—	—	—	4	2	83
	1956	30	—	—	46	—	—	—	10	7	76
	1957	41	2	2	57	—	—	—	10	7	102
	1959	23	4	5	170	—	—	—	14	7	202
Cincinnati, U.	1948	35	10	—	8	—	—	—	—	—	53
	1952	20	10	—	75	—	—	—	—	—	105
	1956	16	8	—	320	—	143	—	—	—	487
	1957	—	—	—	—	—	—	—	—	—	—
	1959	12	8	6	700	—	64	8	18	6	798
Colorado State U.	1948	8	—	2	—	—	—	—	2	—	10
	1952	7	2	5	—	—	—	—	2	—	14
	1956	15	3	20	—	—	—	—	4	—	38
	1957										
	1959	24	5	16	3	—	—	—	4	7	48
Colorado, U.	1948	83	—	—	—	166	—	—	—	—	249
	1952	40	—	—	—	65	—	—	—	—	105
	1956	69	—	—	—	73	—	—	—	—	142
	1957	59	—	—	—	89	—	—	—	—	148
	1959	106	—	—	—	183	—	—	—	—	289
Columbia U.	1948	73	—	—	97	—	—	—	45	2	170
	1952	94	—	—	504	—	—	—	54	3	598
	1956	113	—	—	577	—	—	—	63	13	690
	1957	130	31	73	773	—	—	—	69	22	1,007
	1959	175	43	70	663	—	—	—	65	16	951
Connecticut, U.	1952	15	9	—	138	—	—	—	12	—	162
	1956	8	7	6	78	78	40	—	15	—	217
	1957	9	4	10	73	107	81	—	18	18	284
	1959	11	8	6	81	60	26	—	21	6	192

FOLLOW-UP SURVEY OF ENROLLMENTS AND STAFF IN VARIOUS PATTERNS OF GRADUATE STUDY—*Continued*

FALL SEMESTER ENROLLMENT

Institution	Year	I. Full Time	II. Part-time Grad. Students					III. Co-op	IV. Graduate Faculty		V. Total I + II + III
			Univ. Employed		Ind., Govt. etc., Employed				Full Time	Part Time	
			(a)	(b)	(c)	(d)	(e)		(f)	(g)	
Cornell U.	1948	67	55	7	—	—	—	—	87	—	129
	1952	70	41	24	9	—	—	—	147	—	144
	1956	91	48	31	17	—	—	—	151	—	187
	1957	146	33	†	†	—	—	—	142	—	186
	1959	192	57	34	†	—	—	—	144	—	283
Delaware, U.	1948	—	—	—	—	—	—	—	—	—	—
	1952	—	—	—	—	—	—	—	—	—	—
	1956	30	3	3	—	—	151	—	28	—	187
	1957	30	3	3	—	—	130	—	24	—	166
	1959	33	3	3	—	—	104	—	19	1	143
Denver, U.	1948	—	2	4	—	—	—	—	2	—	6
	1952				Graduate Program was suspended during this period.						
	1956	2	3	5	29	—	—	—	8	2	39
	1957										
	1959	3	1	16	34	—	—	—	10	6	54
Drexel Inst. of Tech.	1948	—	—	—	—	—	—	—	—	—	—
	1952	—	—	—	292	—	—	—	17	7	292
	1956	—	—	—	252	150	—	—	21	25	402
	1957										
	1959	‡2	15	—	510	185	—	—	39	35	713
Florida, U.	1948	68	—	4	—	—	—	—	—	—	72
	1952	34	2	14	—	—	—	—	49	—	50
	1956	34	7	17	1	—	43	—	68	—	102
	1957	24	16	25	10	—	—	—	70	—	75
	1959	65	20	31	13	—	—	—	73	—	129
Georgia Tech.	1948	127	—	—	—	—	—	—	95	—	127
	1952	156	—	4	7	—	—	—	125	—	167
	1956	187	3	15	25	—	—	—	138	—	230
	1957	217	20	35	30	—	—	—	160	—	302
	1959	291	68	75	47	—	—	—	204	—	491
Idaho, U.	1948	9	6	5	—	30	—	—	20	15	50
	1952	4	4	2	—	50	—	—	20	20	60
	1956	6	5	6	—	100	—	—	20	33	117
	1957	4	5	6	—	105	—	—	25	35	120
	1959	10	9	18	—	110	—	—	35	35	147
Illinois, U.	1948				Accurate information not available.						
	1952	285	38	153	—	—	—	—	149	—	476
	1956	286	119	211	—	—	—	—	189	—	616
	1957										
	1959	506	157	262	—	—	—	—	200	—	925
Illinois Tech.	1948	183		§526		85	—	—	134	20	794
	1952	183		§320		45	—	—	117	18	548
	1956	214		§307		—	—	—	122	18	521
	1959										571†
Iowa State U.	1948	46	66	45	—	—	—	—	39	—	157
	1952	24	45	49	—	—	—	—	39	—	118
	1956	41	60	59	2	—	50	2	45	—	214
	1957										
	1959	55	96	66	14	—	42	1	49	7	274
Kansas S. U.	1948	1	40	20	—	—	—	—	44	—	61
	1952	2	14	11	—	—	—	—	40	—	27
	1956	2	29	13	—	—	—	—	46	—	44
	1957										
	1959	40	40	38	3	—	—	—	52	—	121
Lehigh U.	1948	22	(a, b, c— 70)			—	—	—	37	—	92
	1952	24	(a, b, c— 71)			—	—	—	37	—	95
	1956	30	(a, b, c—114)			—	—	—	48	—	144
	1957	54	(a, b, c—243)			—	—	—	60	—	297
	1959	52	(a, b, c—276)			—	—	—	62	—	328

FOLLOW-UP SURVEY OF ENROLLMENTS AND STAFF IN VARIOUS PATTERNS OF GRADUATE STUDY—*Continued*

FALL SEMESTER ENROLLMENT

Institution	Year	I. Full Time	II. Part-time Grad. Students					III. Co-op	IV. Graduate Faculty		V. Total I + II + III
			Univ. Employed		Ind., Govt. etc., Employed				Full Time	Part Time	
			(a)	(b)	(c)	(d)	(e)		(f)	(g)	
Louisville, U.	1948	17	2	—	8	—	—	—	10	—	27
	1952	14	3	1	16	—	—	—	14	—	34
	1956	18	7	1	22	—	—	—	15	—	48
	1957	27	7	—	29	—	15	—	16	—	78
	1959	27	7	—	30	—	—	—	17	—	64
Maryland, U.	1948	48	8	5	50	30	67	—	12	14	208
	1952	40	8	8	90	30	89	—	15	15	265
	1956	40	5	8	110	30	77	—	17	16	270
	1959										421
M. I. T.	1948	841	227	311	145	—	—	—	397	—	1,524
	1952	814	300	446	319	—	—	—	469	—	1,879
	1956	1,033	359	527	379	—	—	—	530	—	2,298
	1957	1,168	256	610	476	—	—	—	576	—	2,510
	1959	1,365	279	626	442	—	—	—	620	—	2,712
Mass., U.	1948	—	—	—	—	—	—	—	—	—	—
	1952	1	2	—	7	—	—	—	—	—	10
	1956	3	2	—	19	—	—	—	13	—	24
	1957	2	4	—	15	—	—	—	6	—	21
	1959	4	6	—	21	26‖	—	—	18	—	57
Michigan State U.	1948	13	3	—	—	—	—	—	—	—	16
	1952	31	13	3	—	—	—	—	20	—	47
	1956	68	22	4	—	—	—	—	35	—	94
	1957										
	1959	64	67	23	21	31	2	—	60	—	208
Michigan, U.	1948	404	28	49	1	—	25	—	not available		507
	1952	244	14	64	1	—	58	—	not available		381
	1956	416	33	95	2	32	14	—	154	22	592
	1957										
	1959	502	60	108	60	125	8	—	120	37	863
Minnesota, U.	1948	109	144	25	—	—	—	—	48	—	278
	1952	100	84	39	48	—	—	—	50	—	271
	1956	108	100	100	33	—	—	—	57	—	341
	1957	90	100	150	35	—	—	—	68	—	375
	1959	100	86	213	40	—	—	—	77	—	439
Newark	1948	15	—	—	300	—	—	—	28	—	315
	1952	—	2	—	590	—	—	—	53	8	592
	1956	3	4	—	724	—	—	—	53	8	731
	1957	1	11	—	670	—	—	—	32	16	682
	1959	1	7	7	706	—	—	—	38	9	721
New Mexico, U.	1948	5	3	—	1	—	—	—	15	—	9
	1952	21	—	—	22	40	14	—	18	3	97
	1956	9	2	2	40	133	4	—	21	7	287
	1957	16	8	10	207	99	—	—	14	13	340
	1959	16	11	30	258	94	—	—	14	9	409
N. Y. City College	1948	Graduate Program started in 1950.									
	1952	—	—	—	330	—	—	—	21	20	330
	1956	1	1	—	418	—	—	—	29	14	420
	1957	1	—	—	525	—	—	—	37	18	526
	1959	—	—	—	623	—	—	—	35	22	623
New York U.	1948	92	34	11	634	—	—	—	42	15	771
	1952	80	24	54	797	—	—	—	50	17	955
	1956	54	36	37	638	—	—	—	56	15	765
	1957	54	38	23	689	250	—	—	81	43	1,054
	1959	66	30	45	753	356	10	—	87	38	1,260
N. Carolina State	1948	7	42	4	5	—	1	—	32	—	59
	1952	13	20	16	2	—	1	—	37	—	52
	1956	13	39	20	5	—	8	—	38	—	75
	1957	45	47	11	20	—	—	—	38	—	123
	1959	55	52	22	20	2	5	—	48	—	156

FOLLOW-UP SURVEY OF ENROLLMENTS AND STAFF IN VARIOUS PATTERNS OF GRADUATE STUDY—*Continued*

FALL SEMESTER ENROLLMENT

Institution	Year	I. Full Time	II. Part-time Grad. Students: Univ. Employed (a)	(b)	Ind., Govt. etc., Employed (c)	(d)	(e)	III. Co-op	IV. Graduate Faculty: Full Time (f)	Part Time (g)	V. Total I + II + III
Northeastern U.	1948	—	—	—	153	—	—	—	4	2	153
	1952	—	—	—	687	—	—	—	24	20	687
	1956	—	—	—	867	—	135	16	31	25	1,018
	1957	—	15	11	1,393	—	273	41	28	54	1,707
	1959	—	12	2	1,101	—	212	79	27	42	1,392**
Northwestern U.	1948	45	29	16	21	—	—	—	33	3	111
	1952	38	14	10	42	—	—	—	32	2	104
	1956	74	27	34	120	—	—	—	39	5	255
	1957	120	30	15	112	—	—	—	38	7	277
	1959	156	40	22	129	—	—	—	46	10	347
Oregon State	1948	46	4	—	—	—	6	—	38	—	56
	1952	20	3	—	—	—	17	—	40	—	40
	1956	26	3	—	—	—	28	—	40	—	57
	1957	33	16	3	—	—	13	—	56	—	65
	1959	61	13	3	—	—	††	—	62	—	77
Penn State U.	1948	23	42	25	—	—	6	—	42	—	96
	1952	27	36	30	2	—	11	—	46	—	106
	1956	29	45	41	21	—	20	—	48	—	156
	1957										
	1959	28	67	77	59	—	51	—	68	3	282
Pennsylvania, U. (Moore School only.)	1948	57	5	10	241	—	—	—	12	—	313
	1952	70	5	10	566	—	—	—	15	2	636
	1956	65	5	10	756	—	—	—	22	1	821
	1957	114	5	10	645	—	—	—	29	2	794
	1959	167	6	18	824	—	—	—	35	3	1,015
Pittsburgh, U.	1948	41	12	1	191	48	5	—	11	7	298
	1952	14	16	2	239	242	20	—	14	9	533
	1956	21	26	3	302	104	15	27	14	20	498
	1957	15	34	6	412	—	49	10	41	8	526
	1959	26	30	7	407	—	59	—	32	47	529
Polytechnic Inst. of Brooklyn	1948	142	22	—	1,041	—	—	—	200	276	1,205
	1952	81	13	—	1,387	—	235	—	141	262	1,716
	1956	89	5	17	1,205	—	249	—	183	290	1,565
	1957	102	25	61	1,287	—	325	—	192/102	279	1,800
	1959	258	30	65	1,409	—	466	—	209/116	185	2,228
Purdue, U.	1956	277	68	93	—	78	—	—	179	1	516
	1957	233	229	347	—	109	—	—	255	—	918
	1959										898†
R. P. I.	1948	101	140‡‡	35‡‡	64	—	—	—	not available		340
	1952	44	50	19	181	—	—	—	120	18	363
	1956	75	80‡‡	22‡‡	150	355	—	—	131	44	682
	1957	142	120	29	227	444	10	2	140	48	974
	1959	150	130	34	188	498	14	—	143	48	1,014
Rutgers U.	1948	—	6	14	5	54	—	—	—	—	79
	1952	—	1	7	3	135	—	—	—	—	146
	1956	3	6	2	16	69	—	—	—	—	96
	1957										
	1959	3	9	3	41	—	—	—			56
Southern Methodist U.	1948	No Graduate Program at this time.									
	1952	—	—	—	169	—	151	—	9	8	320
	1956	—	2	—	178	—	698	—	11	35	878
	1957	6	4	—	291	—	774	—	25	36	1,075
	1959	14	4	2	287	—	378	—	18	27	685
Stanford U.	1948	(250—a and b)			5	—	—	—	—	—	255
	1952	(264—a and b)			10	—	—	—	—	1	274
	1956	(415—a and b)			220	—	—	—	—	1	635
	1957	431			225						686
	1959	586	34§§	162	318						1,123

FOLLOW-UP SURVEY OF ENROLLMENTS AND STAFF IN VARIOUS PATTERNS OF GRADUATE STUDY—*Continued*

FALL SEMESTER ENROLLMENT

Institution	Year	I. Full Time	II. Part-time Grad. Students					III. Co-op	IV. Graduate Faculty		V. Total I + II + III
			Univ. Employed		Ind., Govt. etc., Employed				Full Time	Part Time	
			(a)	(b)	(c)	(d)	(e)		(f)	(g)	
Stevens Inst. of Tech.	1948	—	15	40	756	—	—	—	33	31	811
	1952	—	10	12	941	—	265	—	36	31	1,228
	1956	21	20	15	973	—	6	—	44	43	1,035
	1957	15	22	12	952	—	10	—	54	53	1,011
	1959										735**
Syracuse U.	1948										
	1952										
	1956	18	16	31	180	382	—	—	41	3	627
	1957	25	23	27	151	406	—	—	48	3	632
	1959	28	25	35	180	606	—	—	49	3	874
Tennessee, U.	1948	16	29	5	40	46	—	—	14	9	136
	1952	15	9	9	113	63	—	—	22	7	209
	1956	27	26	7	55	126	—	—	23	5	241
	1957	31	22	8	36	100	—	—	22	6	197
	1959	68	24	7	53	147	—	—	24	6	299
Texas A. & M.	1948	56	15	25	8	—	—	—	22	—	104
	1952	40	11	10	3	—	—	—	22	—	64
	1956	75	12	20	2	—	—	—	23	—	109
	1957	57	24	10	3	—	20	—	39	2	114
	1959	116	44	22	28	—	20	—	51	12	230
Texas, U.	1957	86	54	39	32	—	—	—	50	—	211
	1959	118	60	75	27	—	—	—	76	16	280
Virginia Poly.	1948	74	24	—	8	—	—	—	1	5	106
	1952	23	37	—	15	—	—	—	2	18	75
	1956	28	47	—	24	—	—	—	2	27	99
	1957	56	46	12	46	—	—	—	4	48	150
	1959	39	42	14	43	12	—	—	5	56	150
Washington U.	1948	15	4	10	125	—	—	—	12	—	154
	1952	15	5	10	167	—	—	—	20	—	197
	1956	14	21	—	164	—	—	—	26	—	199
	1957										
	1959	24	13	—	181	—	—	—	44	1	242
Wisconsin, U.	1948	164	18	—	—	75	—	—	55	—	257
	1952	103	17	4	—	163	—	—	60	—	287
	1956	140	20	6	172	—	—	—	65	2	338
	1957	116	87	—	207	—	—	—	79	2	410
	1959	172	90	3	287	—	—	—	75	—	552
Yale U.	1948	82	22	—	7	—	—	—	34	—	111
	1952	80	10	—	14	—	—	—	26	—	104
	1956	96	4	—	69	—	—	—	44	—	169
	1959										198‖

* Classified as full-time but not necessarily taking 12–15 units of grad. courses per se.
† Records incomplete.
‡ Winter Term.
§ Includes totals for a, b, and c.
‖ 26 Pittsfield Program.
** Decrease due to separation out of science students.
†† In state of flux. No accurate estimate possible this date.
‡‡ Approximate; obtained from sub-division of other totals.
§§ Combination Teaching & Research Assistantships.
‖‖ U. S. O. E. Report 10/1/59.

Engineering Graduate Study—1959

Principal Enrollments and Degrees Granted

The following list shows institutions having graduate students full-time, or, part-time but university employed (Group I, II a & b) of approximately 100 or more; and/or part-time graduate students employed off-campus, by other than university (Group II c, d & e) of approximately 400 or more.

*Enrollment '59		Institution	Degrees Granted '59	
§Full-time plus Univ. Employed	Total Incl. All Part-time		Master's†	Doctor's†
217	274	Univ. Arizona	17	9
504	591	U. C., Berkeley	173	20
130	832	U. C. L. A.	105	4
205	205‡	Calif. Inst. Tech.	113	17
184	379	Carnegie Tech.	70	21
395	395‡	Case Inst. Tech.	70	7
34	798	Univ. Cincinnati	10	1
106	289	Univ. Colorado	44	6
288	951	Columbia Univ.	196	26
283	283	Cornell Univ.	70	24
17	713	Drexel Institute	98	—
10	531	Geo. Wash. Univ.	53	—
116	129	Univ. Florida	44	—
444	491	Ga. Inst. Tech.	70	6
925	925	Univ. Illinois	224	45
250?	571†	Illinois Inst. Tech.	66	7
217	274	Iowa State U.	53	12
148	159‡	Univ. Iowa	26	9
118	121	Kansas State U.	28	1
328	328	Lehigh Univ.	59	5
2,270	2,712	Mass. Inst. Tech.	624	97
45?	421	Univ. Maryland	20	4
154	208	Michigan State U.	51	15
670	863	Univ. Michigan	325	44
399	439	Univ. Minnesota	85	13
100	108‡	Missouri Sch. Mines	29	3
57	409	Univ. New Mexico	26	—
15	721	Newark College	124	—
—	623	N. Y. City Coll.	48	—
141	1,260	New York Univ.	267	8
129	158	N. Carolina State	46	4
14	1,392	Northeastern	73	—
218	347	Northwestern	62	24
377	644‡	Ohio State Univ.	111	20
233	316†	Oklahoma State U.	76	5
145	145‡	Oklahoma, Univ.	54	—
172	282	Penn State U.	63	11
191	1,015	Univ. Pennsylvania	107	4
63	529	Univ. Pittsburgh	79	6
353	2,258	Poly. Inst. Bklyn.	149	20

ENGINEERING GRADUATE STUDY—1959

PRINCIPAL ENROLLMENTS AND DEGREES GRANTED—*Continued*

*Enrollment '59		Institution	Degrees Granted '59	
§Full-time plus Univ. Employed	Total Incl. All Part-time		Master's†	Doctor's†
162	162†	Princeton U.	54	14
230?	898†	Purdue Univ.	212	26
314	1,014	Rensselaer Poly.	171	16
846?	1,266‡	Univ. So. California	218	1
20	685	So. Methodist U.	46	—
805	1,123	Stanford Univ.	246	31
50?	735	Stevens Inst. Tech.	121	—
88	874	Syracuse Univ.	47	4
99	299	Univ. Tennessee	47	1
182	230	Texas A & M	62	1
253	280	Univ. Texas	68	14
597	597‡	Univ. Washington	56	1
265	552	Univ. Wisconsin	102	28
120?	198	Yale Univ.	70	16
14,696*	33,000*	Total 54 Institutions	†5,528	†651
		% Total ECPD Schools	84%	91%
	34,374†	Total ECPD Schools	†6,562	†714

* Unless otherwise noted these enrollments based on reports directly from institution. Where larger than U. S. O. E. Reports, students not yet degree candidates may be included.

† Reference: U. S. Office of Education Report as of October '59.

‡ Not reported on in detail tables. U. S. O. E. Report statistics used in this summary only.

§ Geographic full-time on campus in full-time study or part-time study with university employment in research or teaching.

NEW UNIVERSITY, NEW DEAN

Dr. Thomas F. Irvine, Jr., professor of mechanical engineering at North Carolina State College, has been named Dean of Engineering for the State University of New York, Long Island Center, effective February 1.

Announcement of the appointment was made by Prof. John F. Lee, head of the college's Department of Mechanical Engineering and president-elect of the newly-established New York university.

Engineers and/or Scientists

ERIC A. WALKER

President, The Pennsylvania State University and President of ASEE 1960–61

Every satellite that goes into orbit, we often hear, is a scientific success; while every one that does not is an engineering failure. This, of course, is sheer nonsense. Statements of this sort can exist as anything except weak jokes only because people—many people, at any rate—seem not to know or to understand the difference between science and engineering.

As difficult as it sometimes is to draw the distinction in actual practice, science and engineering are clearly *not* the same thing. Science aims at the discovery, verification, and organization of fact and information. Its goal is an understanding of the world we live in and of ourselves as part of that world. It seeks truth and knowledge. The scientist puts nature under his microscope to discover how it behaves and why it behaves that way. Having done this, he seeks to order the facts he discovers into general, or "universal," laws through induction and hypothesis—laws that can stand as an accurate, quantitative description of the organization and operation of nature.

We get "science" from the Old French word meaning "to know"; "engineering" derives from the Old French word meaning "to produce." To an engineer, knowledge is not an end in itself but is simply the raw material from which he fashions structures, machines, and processes. He directs his attention primarily not to the discovery of facts and information but to their application and utilization. His task is to take the knowledge acquired through the study of an existing system—that is, nature—and use it to design a new system to serve a human purpose. If science is basically analytical, engineering is basically creative. If the characteristic method of the scientist is induction, then that of the engineer is deduction. If understanding is the basic goal of the scientist, then utilization is the basic goal of the engineer.

The distinction here is very similar to the distinction between the semanticist and the writer, the phonetist and the actor, or in general, the scholar and the artist. In fact, engineering is traditionally described as an art. Study and investigation take the scientist in the direction of discovery; practice and application carry the engineer toward creation.

Historically and characteristically, science has used the adjective "theoretical" to describe its activities, while engineering has insisted upon the adjective "practical." Actually, the use of these words is not now of much help to us. The engineer's "practical application" is apt to be based upon scientific theory, whereas the scientist's "theoretical" study of the behavior of the atom might easily lead to a very practical method of preserving foods. If, by "theory," we mean the drawing of inferences from observed and verified facts, then the engineer is constantly concerned with it. If, on the other hand, we mean to imply a separation from reality, then science—the study of physical phenomena—cannot properly be involved with it. If, by "practical," we mean "useful," then science has been the most practical of all disciplines, as it has given us the base upon which we have erected a large segment of our culture and our economy. And, if, by it, we mean to imply a preoccupation with the time-tested and the conservative, then it hardly applies at all to engineering, with its emphasis upon the creative design of new machines, new materials, new processes, and the like.

Even though a clear-cut distinction can be made, science and engineering do not exist in separate vacuums mutually exclu-

sive of each other. The fact that engineering depends upon science for the raw material from which it creates its designs is clearly understood, I believe. Less clearly understood is the corollary that science depends upon engineering for the tools with which to carry out its investigations. The scientific study of atomic behavior in producing the light and heat of the stars resulted in information that made it possible for engineers to design reactors. These reactors, in turn, permitted the scientists to refine their knowledge, producing information that enabled the engineers to harness nuclear energy in generating electricity, in preserving foods, and the like. The design of huge electronic computers, an engineering achievement, has opened up vast new fields of inquiry for the scientists. Scientific investigations into solid-state physics are opening up completely new areas of applications for engineers.

This interdependence is often seen in the work of a single man. To study the structure of atoms, Edwin Mueller, a physicist at The Pennsylvania State University, used information from the scientific study of optics to invent the ion microscope, an outstanding engineering achievement. The basic, scientific information he discovers through the use of his invention will undoubtedly be put to use in a wide variety of applications. To develop an effective vaccine for polio, Dr. Jonas Salk found it necessary to conduct a scientific exploration of the behavior of the polio virus. This means that he turned scientist to provide himself with the information he needed to solve an "engineering" problem.

In Russia, incidentally, this distinction seems to be drawn somewhat more carefully than it is in the United States. Russia, we are now told, concentrates to a much greater extent upon the training of engineers than we do here in America. But in Russia practically all the physical scientists are engaged in teaching and research, with almost none going into industry and management. Engineers, on the other hand, are used to a much wider extent in management and administration than they are here in the United States. Whereas in America many chemists, for instance, find occupation in "applied chemistry" with drug concerns and other industrial organizations, in Russia these positions are filled with chemical engineers. In fact, the Russian economy is largely run by people trained as engineers.

There are several reasons for enforcing this distinction. One of these involves the removal of the growing stigma that seems to attach to the word "engineer." For some strange reason, engineering and engineers are losing prestige and favor in the United States. Yet never before in our history have we needed more to find new and constructive ways to utilize knowledge and fact. Perhaps the engineers themselves are partly at fault. By emphasizing "how to," as they have done at times in the past, they have called attention to the craftsmanship aspect of their profession and, by implication, deemphasized its creative aspects. By insisting on the word "practical," they have perhaps led people to believe that they lacked imagination and concern for progress. After all, neither the "practical businessman" nor the "practical politician" could pass a Madison-Avenue "image" test.

Whatever the reason, we seem, here in America, to be turning more and more to physicists and chemists and the like for jobs that involve design and utilization—jobs for which they are not prepared and for which engineers *are* prepared. A design problem does not become something else simply because we assign it to a scientist rather than to an engineer. Nor does a further multiplication of knowledge eliminate the need to solve the problem. We must recognize that knowledge, in and of itself, is sterile and useless. It becomes important only after it has been put to use in the affairs of man. This is the job for which engineers are specifically trained. This is the work to which they are committed. No one else can do it as well as they.

Secondly, this distinction draws attention to the essential moral obligations of engineering. Although scientists share with other human beings certain moral obligations, the gathering of facts and information is not, in itself, an activity

that involves morality. Facts and information are morally neutral. They can be used to advance evil purposes as easily as they can be used to advance virtuous ones. And, unless they *are* put to use, they advance nothing except the erudition of the person who gathered them.

But engineering is fundamentally committed to the translation of scientific facts and information to create machines, structures, materials, processes, and the like that can be used by men. This is, by its very nature, an activity that *does* involve morality. This fact has been recognized –and accepted–by leading engineers. The Recognition Committee of the Engineers' Council for Professional Development has proposed a definition of engineering, for instance, that states, in part, that "Engineering is the profession in which knowledge . . . is applied with judgment . . . for the progressive well-being of mankind." The phrases "with judgment" and "progressive well-being of mankind" involve more than "know how," more than craftsmanship. They involve value judgments. They involve social decisions. They involve leadership in what *should* be done as well as in what *could* be done. They involve moral responsibility–a moral responsibility for the direction taken by our civilization and for the sort of lives we live in it. It is a responsibility that engineering can deny only by admitting that it, too, is only a machine and engineers only the workmen that keep the machine functioning. Some people have suggested that the engineers' contribution to "planned obsolescence" has taken them a long way toward this admission.

Finally, this distinction has definite implications for the training of engineers. Traditionally, an advanced degree is awarded, in part, on the basis of an original contribution to the field. And this original contribution is normally expected to consist of an addition to the body of knowledge in the field. This, it would seem, should provide a sound training for the future scientist. It provides the graduate student with the opportunity to learn and to *practice* the methodology of research in a "real life" situation under the guidance of an experienced scientist.

But, as we have seen, an engineer is not a scientist. For an experience of similar significance and relevance, the advanced engineering student must be given the opportunity to practice engineering, not science. For this, he must be given the opportunity to learn and to practice design, to create something new, rather than to explore why and how something works that already exists. A person does not learn to paint by studying art criticism. Rather, he learns to paint by painting under the guidance of a competent artist. Nor does a person become an engineer by studying the procedures of science. He learns, if he is going to learn, through the successful completion of a design problem. You do not learn how to fashion new machines by taking old ones apart. Nor do you learn creativity by practicing analysis.

There are lessons to be learned here, also, by the faculties of our colleges and schools of engineering. To guide their students, professors of engineering should maintain their proficiency as engineers. This means that they must continue to practice engineering–that is, they must continue to be involved in the design and creation of new machines, new systems, and the like. Characteristically, professors at our medical schools are also practicing physicians and surgeons. They keep abreast of their field of expertise through actual practice. Traditionally, professors of physics and chemistry are also practicing scientists, who do much of their teaching by permitting their students to work alongside them as apprentices. Professors of engineering, to be most effective in their teaching, should also be practicing engineers, or, at least, consulting engineers in a position to see and experience at first hand the solution of difficult design problems by competent practicing engineers.

If the knowledge we discover is to mean anything to us, is to be of any value to us, we must continue to honor and to teach its use through creative engineering design. Science without engineering will lead to erudition without progress, to knowledge without advance, to intellectual dilettantism and creative sterility.

The Ph.D. Program in the Engineering Sciences at The University of Oklahoma

W. H. CARSON

Dean

C. M. SLIEPCEVICH

Associate Dean
College of Engineering, University of Oklahoma, Norman, Oklahoma

Two years ago, the College of Engineering with the assistance of the Graduate Council undertook an experimental program which was referred to as the Ph.D. in the Engineering Sciences. This particular program was nurtured from necessity. Up to this point, the only department in the College of Engineering which was authorized to grant the Ph.D. was Chemical Engineering. Several of the other departments had active graduate programs on the master's level but none of these had a sufficient number of staff members with Ph.D. degrees themselves to qualify for granting the Ph.D. According to the policy of the Graduate Faculty, there was considerable reluctance to approve a Ph.D. program in a department which did not have at least three Ph.D.'s on its staff.

A survey of our faculty as a whole in the College of Engineering revealed that in each department there were several staff members who were vitally interested in developing a Ph.D. program. It was also evident that we were faced with a chicken and egg proposition. In attempting to recruit new staff, we found it difficult to attract outstanding Ph.D.'s into departments that did not have an established Ph.D. program. On the other hand, it was quite obvious that we could never have the latter without the former.

The next course of action was the inevitable. A committee composed of faculty from the College of Engineering and chaired by Dr. O. K. Crosser of Chemical Engineering set about to make a study of this dilemma. After much deliberation (and without benefit of outside financial support) the committee decided that the only possibility for getting a Ph.D. program off the ground in the College of Engineering was to pool all the research and graduate-oriented faculty in engineering and the physical sciences into a hypothetical department. This department was labeled Engineering Sciences, principally to stay abreast of the then current vogue that engineers had to identify themselves with science or perish as members of a discipline in itself. To administer the programs it was recommended that a Graduate Standards Committee of the College of Engineering be appointed. This committee was to consist of three representatives from the College of Arts and Sciences, one each from Mathematics, Physics, and Chemistry, and three representatives from the College of Engineering. The Associate Dean of the College of Engineering was designated as chairman.

In January, 1957, the Faculty of the College of Engineering approved the committee's recommendations and forwarded them to the Graduate College. The Graduate Council in turn appointed a University-wide committee to evaluate this proposal and finally in December, 1957, the Graduate Faculty implemented the program officially when Graduate Dean L. H. Snyder appointed a Graduate Standards Committee composed of Dr. J. B. Giever (Mathematics); Dr. R. A. Howard (Physics); Dr. E. E. Bym (Chemistry); Dr. O. K. Crosser (Chemical Engineering); Dr. W. R. Upthegrove (Metallurgical Engineering); Dr. C. G. Dodd (Petroleum Engineering) with Dr.

C. M. Sliepcevich (Associate Dean of Engineering) as Chairman. Shortly thereafter the committee held its first meeting, and it established the following requirements for the degree:

1. A minimum of 60 hours of course work (four semesters) beyond a Bachelor's degree in engineering, the physical sciences, or mathematics. Of this 60 hours, a minimum of 20 hours of graduate work must be taken in the physical sciences or mathematics. The requirement in mathematics is further specified as at least nine hours beyond calculus.

2. A reading proficiency in two foreign languages, one of which must be either German or Russian.

3. Completion of two major, comprehensive problems in fields unrelated to each other and also to the dissertation. The candidate must generate these problems on his own, and they must be original in nature. One problem is directed toward a basic research study and includes a literature survey, statement of the problem, detailed outline of the experimental attack and data to be taken, detailed development of the theory associated with the problem, and a probable method for interpreting and correlating the data. The other problem is pragmatic; it is directed to an engineering design of a new process or device substantiated by detailed economics.

Both of these problems must be defended in an oral examination before a committee of faculty appointed by the Graduate Dean. The committee is at liberty to ask any questions whether related to the special problems or not. If any weaknesses in the candidates background become evident during the oral examination, the committee is empowered to give the candidate a written, comprehensive examination within 30 days following the oral. The committee may also request the candidate to do another comprehensive problem. If the candidate passes the oral examination, he is permitted to proceed with his doctoral dissertation. If the candidate does not pass the oral examination or written comprehensive, he is not permitted to continue toward the Ph.D. At this point, he can usually qualify for a master's degree.

The concept of using two major comprehensive problems rather than the usual qualifying examinations over previous course work is to emphasize the research aspects of the Ph.D. degree. It is felt that this objective can be realized more effectively by requiring the candidate to become reasonably familiar in three fields rather than in just the field of his dissertation. Further, more is to be gained from original thought given to two problems outside the dissertation field than to a series of written examinations. The latter serves no realistic purpose if the candidates are carefully screened prior to acceptance into the program. The Graduate Standards Committee is rather sensitive about not having this program degenerate into an obstacle course which must be hurdled by one means or another. Their ultimate objective is to encourage the development of research talents.

4. The candidate must complete a dissertation and defend it at an oral examination.

Administration of the degree is relatively simple:

1. The applicant must first be admitted to the Graduate College of the University.

2. If he is admitted, he is interviewed by the Graduate Standards Committee of the College of Engineering. If accepted by this committee, he is advised regarding his program.

3. As soon as the applicant has progressed far enough along to determine what his general field of interest is with respect to a dissertation, the Graduate Standards Committee recommends to the Graduate College that a special Doctoral Committee be appointed to advise the student. Once appointed, this committee follows the student through the remainder of his program. It is responsible for conducting the oral and written examinations on the special problems as well as the dissertation. However, the committee is free to invite specialists from the University and from outside the University to assist them whenever they

feel it is desirable. The Graduate Dean also reserves this right.

When this degree was first established, it was thought that ultimately as the program grew, individual departments would gradually be authorized to grant the Ph.D. when they could meet the staff requirements acceptable to the Graduate College. For this reason, the School of Chemical Engineering continued to offer the Ph.D. even though its requirements for the degree are identical to the Engineering Sciences. All other degree-granting departments in Engineering operate under the Engineering Sciences graduate program; these departments include Aeronautical and Space, Civil, Electrical, General, Geological, Industrial-Management, Mechanical, Metallurgical, and Petroleum Engineering, Theoretical and Applied Mechanics, and Engineering Physics. The degree is in Engineering Sciences rather than the department of specialization. Considering the success of this program, there is no real justification for initiating Ph.D. programs in specialized fields of engineering nor for continuing the Ph.D. in Chemical Engineering except as it may have some traditional value.

There are five principal bonuses that arise from a program of this kind:

1. All departmental lines vanish. A student feels free to do his research in a field and under the most qualified University professor in that field regardless of the student's previous area of specialization. For example, the first student to complete the Ph.D. in the Engineering Sciences had a master's degree in electrical engineering from Columbia University. His thesis for the Ph.D. in the Engineering Sciences was done under Professor Giever in Mathematics on a rather abstract mathematical treatment of network analysis. Presently, about half of the Ph.D. candidates are working in areas outside their previous field of specialization. Considering the true meaning of the Ph.D., this trend is consistent; in the past it has been discouraged principally because of traditional departmental barriers.

2. Because of its flexibility, this program is as suited to students whose undergraduate preparation is in the pure sciences or mathematics as for engineers. A number of the present candidates came from the pure sciences. They have the alternative of continuing their Ph.D. work in the pure sciences or going the engineering sciences route if their interests on the graduate level lean more toward the applied sciences. In such cases, physicists and mathematicians usually tend toward electrical or metallurgical engineering, or applied mechanics; chemists convert readily to chemical or petroleum engineering, etc.

3. Greater familiarity with the research programs in the various areas is achieved by the natural and close association of the students and faculty in engineering and the sciences.

4. The tendency toward proliferation of course duplications on the *graduate level* among individual departments is essentially eliminated.

5. Both uniform and high standards can be maintained in the graduate program throughout the College of Engineering regardless of area of specialization.

In the two years since this program has been in effect, it has grown to forty candidates. By 1961, it is estimated that well over a hundred students will be enrolled. This program has unusual merit in every respect, particularly for those schools that are initiating a Ph.D. program in engineering. In any case, it certainly provides a mechanism for maximum utilization of faculty research talent.

ANNUAL MEETING JUNE 26–30
UNIVERSITY OF KENTUCKY, LEXINGTON

The Relative Merits of Lecture and Recitation in Teaching College Physics

OTIS E. LANCASTER

Westinghouse Professor of Engineering Education

KENNETH V. MANNING

Associate Professor of Physics

MARSH W. WHITE

Professor of Physics

OTHER MEMBERS OF THE PHYSICS DEPARTMENT

Pennsylvania State University, University Park

The Pennsylvania State University's Physics Department was contemplating a modification of their instruction in physics. They were thinking about reducing the number of recitation periods and increasing the number of lecture periods by the same number. This modification would permit, for a fixed number of students, a reduction in the number of professor-classroom hours. At the same time it was felt by some members of the department that the amount of material presented could be increased. In this manner the curriculum could be enriched. Not all of the members of the physics department shared these views on the advantages of more lectures, and over 80% of the students had expressed a preference for more recitations and fewer lectures. Thus, it was deemed that a careful scientific investigation of the effectiveness of a lecture versus a recitation period should be conducted before any permanent changes would be made.

The procedure for the evaluation and the results presented here were obtained through the co-operation of the Physics Department, the College of Physics and Chemistry, and the College of Engineering and Architecture. This experiment was conducted in the usual second semester course in physics which treats the subjects of electricity and magnetism, and light.

Presented at the Annual Meeting of ASEE, June, 1960. Recommended by the Educational Methods Division.

Summary

The achievement of the students increased significantly as the number of recitations increased and the number of lectures decreased.

The unadjusted average scores on all the tests are given in Table I for all students other than engineering science students. Table II gives the results for engineering science students.

The results of the three tests and the one 2-hour final were combined by weighting the hour tests by 1 and the final by 2, i.e., the number of hours involved. The results were then adjusted to account for the differences in the student's ability, based upon their grades in the first physics course (235).

According to the F-test (Appendix B) the chance that these results would occur by chance is much less than 1 in 100 (F for 1–100 is 4.66, the F here was 4.69). Thus, the difference was highly "significant."

Table IV shows that the results of better achievement of the students with three

TABLE I

UNADJUSTED GRADES OF STUDENTS IN PHYSICS 236 EXCLUSIVE OF ENGINEERING SCIENCE STUDENTS

	Test 1		Test 2		Test 3		Final Exam	
	N	Av. Score	*N*	Av. Score	*N*	Av. Score	*N*	Av. Score
3R–1L	220	53.31	214	51.91	204	64.75	201	48.85
2R–2L	120	48.73	119	49.84	112	63.11	111	45.96
1R–3L	225	53.52	221	47.41	210	61.84	206	44.13

TABLE II

UNADJUSTED GRADES OF ENGINEERING SCIENCE STUDENTS

	N	Test 1	Test 2	Test 3	Final Exam
3R–1L	19	68.89	74.89	75.26	61.47
1R–3L	7	66.42	67.57	77.00	60.14

recitations and one lecture over those students with one recitation and one lecture persisted for all curricula, even though in many incidences, the number of students was small. Because of the small numbers involved, the monotone increasing performance with an increasing number of recitations was not maintained in all curricula.

The analysis indicates that the differences cannot be attributed to differences in teachers or to any other assignable cause; it was concluded the results were due to the treatments.

Procedure

1. *Type of Instruction*

To test the achievement made in instruction by lecturing with that of instruction by recitations, the second physics course for engineers, on the subject of electricity, magnetism and light, was given by three distinct procedures:

3R–1L 3 recitations, 1 lecture and 1 practicum per week
2R–2L 2 recitations, 2 lectures and 1 practicum per week
1R–3L 1 recitation, 3 lectures and 1 practicum per week

All groups follow the same general outline of subject matter.

For those classes with three lectures

TABLE III

GRADES IN FIRST PHYSICS COURSE, SECOND PHYSICS COURSE AND ADJUSTED GRADES IN SECOND COURSE

Non-Engineering Science Students Taking all Tests

	N	Physics 235	Physics 236	Physics 236 Adjusted
3R–1L	197	77.95	54.50	54.21
2R–2L	109	76.64	51.43	52.24
1R–3L	205	77.77	51.08	50.94

TABLE IV

GRADES OF ENGINEERING STUDENTS BY CURRICULUM

	N	Phys. 235	Phys. 236	Phys. 236 Adjusted
Aero Engineering				
3R–1L	21	78.07	56.49	56.09
2R–2L	12	74.50	55.20	57.81
1R–3L	21	78.54	47.44	46.65
Agricultural Engineering				
3R–1L	4	78.5	53.5	52.74
2R–2L	4	72.2	45.0	49.54
1R–3L	5	72.6	48.2	52.41
Architectural Engineering and Architecture				
3R	11	72.72	47.91	52.01
2R	7	76.86	51.43	52.05
1R	13	72.08	46.00	50.64
Chemical Engineering				
3R–1L	18	84.72	60.67	54.68
2R–2L	23	83.57	57.61	52.59
1R–3L	17	82.71	55.35	51.05
Civil Engineering				
3R–1L	27	76.20	52.32	53.50
2R–2L	10	74.90	44.00	46.27
1R–3L	15	74.53	45.13	47.71
Electrical Engineering				
3R–1L	62	78.32	55.87	55.26
2R–2L	25	75.27	52.34	54.30
1R–3L	77	80.87	57.10	54.35
Engineering Science				
3R–1L	19	87.37	68.37	60.15
1R–3L	7	90.57	66.29	55.38
Industrial Engineering				
3R–1L	15	75.36	47.12	49.00
2R–2L	1	82.00	59.00	55.30
1R–3L	15	75.80	44.20	45.71
Mechanical Engineering				
3R–1L	26	78.6	54.49	53.65
2R–2L	20	74.60	47.70	50.22
1R–3L	39	75.70	46.60	48.20

TABLE V

ADJUSTED AVERAGE COMPOSITE GRADES BY SECTIONS EXCLUDING ENGINEERING SCIENCE STUDENTS

Section		N	235	Unadjusted 236	Adjusted 236
	4	14	76.14	47.14	48.37
	9	27	77.33	53.44	53.67
	10	20	79.35	55.15	53.68
	12	21	76.62	56.57	57.39
3R	20	26	79.23	53.46	52.09
1L	22	30	74.00	53.96	56.99
	28	22	77.77	59.09	58.95
	32	19	75.84	56.58	58.06
	44	18	78.61	53.28	52.43
Average		197	77.95	54.50	54.21
	7	17	80.41	56.29	53.93
	8	15	74.00	49.53	52.56
2R	18	22	75.78	48.68	50.29
2L	29	15	75.60	51.67	53.35
	36	22	74.04	52.04	55.03
	38	18	80.27	50.83	48.58
Average		109	76.64	51.43	52.24
	1	14	75.00	43.29	45.48
	2	12	73.92	44.41	47.50
	3	13	78.77	48.92	47.94
1R	13	14	78.00	56.21	55.87
3L	14	16	80.31	53.32	51.04
	19	12	77.83	57.67	57.48
	34	12	73.58	44.67	48.05
	39	14	80.64	46.14	43.58
Sub. Av.		107	77.42	49.48	49.63
	5	11	78.09	53.45	53.04
	6	11	85.00	56.73	50.51
	15	16	81.50	61.06	57.78
	17	15	78.67	49.80	48.90
	24	10	77.20	48.20	48.54
	37	8	74.25	43.25	46.06
	40	13	78.31	59.77	59.17
	45	14	71.21	51.08	50.80
Sub. Av.		98	78.15	52.82	52.36
Average		205	77.77	51.08	50.94

per week, the demonstrations, the development of the theory and the discussion of illustrative problems were given during the lectures to about 120 students. The recitation classes composed of about 15 students each were devoted to the clarification of concepts and the discussion of assignments.

In the second case, classes with two lectures, the demonstrations and some of the development of the theory were given in the lectures to about 120 students. The illustrative problems and the completion of the theoretical development were treated in the recitation periods, with classes of about 24 students.

In the first case, classes with one lecture and three recitations, the demonstrations and the accompanying theory were given in the lecture for 120 students. The other basic theory and the illustrative problems were discussed during the recitation periods, with classes of about 24 students.

The laboratory sections (practicum) were composed of about 15 students and were conducted in the same way for all three groups.

2. *Selection of Students*

To admit a valid interpretation of the experiment, it was necessary that the students for the three treatments be selected at random.

For the most part the ones who take this course are engineers. Within each curriculum, for regular students, the courses are prescribed; hence once a pattern for the curriculum has been determined, any regular student can take his courses according to this schedule pattern. The number of schedule patterns required for each curriculum were constructed and listed in the Official University Time Table e.g. EE Group A, EE Group B, . . ., CE Group A, CE Group B, . . . and so forth. The schedule patterns for each curriculum included instruction by each of the three procedures.

A careful roster of all students in each of the engineering curriculums was compiled prior to registration. By use of a table of random numbers, the students within each curriculum were assigned by name to one of their groups, that is, to one of the three types of instruction. This was fairly straightforward for the regular third semester students. Much greater detail and care were required to distribute randomly the irregular students —those who were out of phase as a result of transfer, failure, or summer course.

There were about 600 students. The general scheme was to have:

240 students with treatment 3R–1L
120 students with treatment 2R–2L
240 students with treatment 1R–3L

If there had been more students, then the plan would have envisioned equal numbers in all groups. Moreover, the general plan was to have been carried down to each of the curriculums, ⅖, ⅕, and ⅖ of the students to each of the three types of instruction. However, because of the necessity for keeping all other classes of the desired size and because some of the curriculums' groups did not have enough students for a section, it was not possible to maintain this ⅖, ⅕ and ⅖ proportion. Nevertheless, within the degrees of latitude, the students were randomly selected; and the lists of names of all of the students, by groups, were prepared before registration, including any special notations required for registration. At the time of registration there were a few students who changed curriculums. An attempt was made to handle these in a random manner. Two pitfalls did appear. First, more engineering science students, an honors group, were scheduled for the 3R–1L than planned. Second, some of the students listed in Section 4 were left in Section 22 all semester. The treatments of these last two sections were the same and the hours the same, but this gave an unbalance to the class size which was not necessary.

3. *Test and Examination*

The same hour tests and final examination were given to all students. In order to have a common hour, the tests were given at night. There were 3 one-hour tests and a two-hour final examination. These tests and the examination were made up by the Physics Department and administered by them. Tests were graded as uniformly as possible by the same two professors grading a single question on all examinations. In addition to the total grades on each "blue book" obtained, a frequency distribution as to the results on each question was made to see if there were essential differences on each type of question since the coverage could not be identical (Appendix C).

Analysis of Results

1. *Correlating Variable*

Even though the students were carefully selected by a random procedure it was still quite likely that the ability of the students in the subgroups would show substantial variability from subgroup to subgroup. Hence a better interpretation of the results could be made if a leveling factor or correlating variable were found. The composite numerical grades the students made in the first college physics course (235) were used for this purpose.

Of the 597 students registered, 462 took Physics 235 the preceding semester. They had been graded in a uniform manner. Of the 114 remaining who took all tests and the final examination, 10 were transfer students, 40 were from the Commonwealth Campuses, and 64 had taken the course on the campus during earlier semesters or during a summer session. A numerical estimate of the grades that these students made in Physics 235 was obtained by a statistical inference from their course grades, and the numerical grades made by the 462 students. The numbers assigned to the letter grades for the 114 students were as follows:

A = 93
B = 85
C = 77
D = 67
Transfer = 83 (Grade had to be C or better)

The distribution of this group to the three types of instruction by chance was as follows:

3R–1L–50
2R–2L–17
1R–3L–47

So whatever the errors in estimating the correlating number, the effect should be small.

It is important to have a correlating variable. This can be seen from the achievement of the 2R–2L group. Their potential was slightly less than that for the other two groups. They actually did poorer on the first test, before the effects of the different treatments had time

to show, and this lower potential should have an influence throughout the semester. A true comparison cannot be seen without a correction for this difference. The two other large groups were so nearly equal in potential that the correction was of little merit. However, it was very important when the subgroups were being considered.

2. *Student Withdrawals*

At the close of registration the number of students enrolled were as follows:

3R–1L....240
2R–2L....124
1R–1L....233

Four more engineering science students were in 3R–1L and four less in 1R–1L than planned. Hence, in the analysis of the data these students were separated.

Before the first examination, 6 students had withdrawn, 4 from the 2R–2L treatment and 1 from each of the others. Since the 2R–2L treatment was the normal method for giving the course, the authors are reasonably sure the treatments did not produce the early withdrawals.

Between the first test and the examination there were additional withdrawals, officially or otherwise. It is interesting to see how evenly they are percentagewise by treatment. They were as follows:

3R–1L	19
2R–2L	9
1R–3L	19

There were a few who because of illness or other legitimate excuses missed some of the tests. Since the make-up tests could not be graded uniformly, the probability analysis here is based on the results from those students who took all tests and the final examination.

3. *Covariance Analysis*

After the test scores and final examination scores were combined for each individual, weighted by 1 and 2 respectively, the hours devoted to them, a covariance analysis [1] was made to determine whether the results were attributable to the different methods of instruction or whether they could be expected by chance when there was actually no difference in the student's achievement. The detailed calculations are given in Tables VI and VII, in Appendix B. The F value of 5.20 would be expected by chance alone less than 1 time in 100. More precisely the 5% and 1% F values given in the usual tables for ascertaining significant differences are 3.02 and 4.66. Hence, the results are highly significant.

[1] Ostle, *Statistics in Research*, Iowa State College Press, 1954, pp. 384–392.

4. *Teacher Effect*

Even though there was a definite difference in the results of achievement, an increasing function with the number of recitations, these results might have come from the difference in effectiveness of the various teachers. Two different lecturers presented the materials to the students in the 1R–3L groups. A covariance analysis revealed that the achievement of the students of one of these lecturers was significantly higher at the 1% level than the achievement of the students of the other lecturer (Table VIII). This indicated a strong teacher effect in the lecturing or in the one hour of recitation. An analysis for the effect of differences between the recitation sections failed to reveal a conclusive difference (Table IX).

It is interesting that the instructional procedures 3R–1L and 2R–2L yielded better results than the better of the two 1R–3L groups. This seems to indicate the results were produced by the procedures and not the teachers, even though the difference between the achievement of the students of the two lecturers for 1R–3L were greater than the difference between the whole of 1R–3L and 2R–2L, or 2R–2L and 3R–1L.

A covariance analysis to determine the effects between teachers in the 3R–1L group again showed there was a significant difference but this time at about the 2% level. The differences in instruction may have been as great yet not so easily identified because of the smaller number of the students in the cells.

The comparative effectiveness of the teacher and procedure combination can be seen from the adjusted means in the right column in Table V. Had the class sizes been the same, the most effective

instructor in descending order by section would have been Sections 40, 28, 32, 15, 19, 12, 22, 13, 36, etc. In more realistic comparison, when these values are corrected for class size, the order would be 28, 32, 22, 40, 12, 15, 19, 13, 36, etc.

The best achievement under the 3R–1L and for the better performance group under the 1R–3L was made in those sections where the lecturer was also the recitation instructor, and in the 2R–2L the performance of the students with the same R and L instructor was better than for the average for the group. Thus, it would appear desirable for the student to have the same instructor in both the lecture and the recitation period. This, in a way, confirms the results obtained by Blumenthal.[2]

The percentage of lost students (drop-out and failures) for the three methods of presentation were 21.24, 27.41, and 30.25 for the 3R–1L, 2R–2L, 1R–3L respectively. The percentage of failures on those students completing the course were 15.12, 20.35, 25.48 respectively.

APPENDIX A

Survey of Student Opinion

PHYSICS 235 AND PHYSICS 236

At the end of the final examination, fall 1957, the students were requested to answer the following questionnaire. There was no requirement that the student answer and he was not required to sign the questionnaire. In Physics 235 there were about 380 students with 286 replies and in Physics 236 there were about 500 students with 379 replies.

The blanks in the questionnaire are filled with numbers indicating the per cent replying that gave *that* response.

Questionnaire

Will you please supply the answers to the following by putting a check in the appropriate blank. Do this either at the end of the exam, or hand it in later at the Physics Office. This will be of help to us in an effort to more effectively teach the physics course. You need not sign the question sheet.

1. The part of the course that helped most to learn physics was: Lecture (8), Recitation (77), Laboratory (13).
2. I would profit by more of the time being used for: Lecture (5) Recitation (89), Laboratory (5).
3. I would profit by less of the time being used for: Lecture (62), Recitation (3), Laboratory (32).
4. Assuming the time distribution unchanged I would profit more in the lecture if the *number* of demonstrations were: increased (46), decreased (16), unchanged (36).
5. I would profit more if lecture included more explanation and less demonstration. Yes (38), No (57).
6. I found the textbook (S-Z) clear (52) confusing (26), other (18).
7. Estimate your numerical grade in this course ————%.
8. In the space below make any comment you wish that suggests any change that would have helped you.

Under "comments" the students reiterated their feeling that recitation was the place they learned the most. They felt that the lecture and the laboratory parts of the course were not profitable in proportion to the time spent on them, and that the quality of the lecturing could be improved. Some students felt that less should be covered in the lecture and more time should be spent in explanation.

There were complaints that the accent of some of our foreign instructors made understanding difficult.

Comments on Results

It is clear that the students' opinions are that they profit more from recitation (77%) and that they would profit *more* from *more* recitation (89%). We should point out that grades are assigned by the recitation instructor. The examinations are written primarily by lecturers and emphasize problem solving, rather than qualitative discussion.

[2] "Split Sections and Learning in College Physics," *American Journal of Physics*, Vol. 25, No. 6 (September, 1957), pp. 352–355.

APPENDIX B

TABLE VI

DATA FOR *F*-TEST

		N	X	Y	X^2	XY	Y^2
All Non-Engineering Science Students							
3R–1L		197	10,737	15,357	613,461	847,649	1,210,631
2R–2L		109	5,606	8,354	303,154	435,127	647,578
	Group						
1R–3L	II	107	5,295	8,284	278,659	415,041	647,488
	III	98	5,177	7,659	292,467	409,491	605,219
	Total	205	10,472	15,943	571,126	824,532	1,252,707
Total		511	26,815	39,654	1,487,741	2,107,308	3,110,914
Engineering Science Students							
3R–1L		19	1,299	1,660	90,859	114,183	145,478
1R–3L		7	464	634	31,322	42,102	57,516
All Students							
3R–1L		216	12,036	17,017	704,320	916,832	1,356,109
2R–2L		109	5,606	8,354	303,154	435,127	647,578
1R–3L		212	10,936	16,577	602,448	866,634	1,310,223
Total		537	28,578	41,948	1,609,922	2,263,593	3,313,910

Regressive Line

Non-Engineering Science $Y = -\ 8.3558 + .7839X$
All Students $Y = -\ 12.4545 + .8407X$

TABLE VII

ANALYSIS OF COVARIANCE

Non-Engineering Science

Source of Variance	Degrees of Freedom	Sums of Squares and Products			Derivations about Regressive		
Among treatments	2	129	202	1,324			
Within treatments	508	33,604	26,242	79,333	58,840	507	116.0552
Total	510	33,733	26,444	80,657	59,927	509	
					1,043	2	521.5

$$F = \frac{521.5}{116.0} = 4.69$$

For $r_1 = 2$, $r_2 = 507$ F values at 5% level *3.02*
at 17% level *4.66*

TABLE VIII

F-TEST FOR DIFFERENCE OF EFFECTIVENESS OF LECTURERS IN 1R–3L TREATMENT

Source of Variance	Degrees of Freedom	Sums of Squares and Products				Derivations about Regressive	
Among teachers	1	27	124	570			
Within classes	203	11,780	9,993	35,616	27,139	202	134.35
Total	204	12,807	10,117	36,186	28,194	203	
					1,055	1	1,055

$$F = \frac{1{,}055}{134.35} = 7.85$$

For $v_1 = 1$, $v_2 = 202$ *F* values at 5% level is *3.89*
at 1% level is *6.76*

TABLE IX

F-TEST FOR DIFFERENCE OF EFFECTIVENESS OF RECITATION INSTRUCTION IN ONE OF 1R–3L GROUPS

Source of Variance	Degrees of Freedom	Sums of Squares and Products				Derivations about Regressive	
Among teachers	3	215	82	350			
Within classes	103	5,922	5,018	16,478	12,227	103	118.7
Total	106	6,137	5,100	16,828	12,590	104	
					363	3	121

$$F = \frac{121.0}{118.7} = 1.02$$

F values at 5% level is *2.70*
at 1% level is *3.98*

TABLE X

F-TEST FOR DIFFERENCE OF EFFECTIVENESS OF RECITATION INSTRUCTORS IN 3R–1L

Source of Variance	Degrees of Freedom	Sums of Squares and Products				Derivations about Regressive	
Among teachers	5	189	16	1,082			
Within classes	191	13,298	10,638	27,186	18,676	191	98.29
Total	196	13,487	10,654	28,268	19,852	195	
					1,176	5	235.2

$$F = \frac{235.2}{98.29} = 2.39$$

For $v_1 = 5$, $v_2 = 190$ *F* values at 5% level is *2.26*
at 1% level is *3.11*

APPENDIX C

FREQUENCY OF GRADE ON EACH QUESTION FOR THE THREE METHODS OF INSTRUCTION-TEST—NOVEMBER 5, 1958

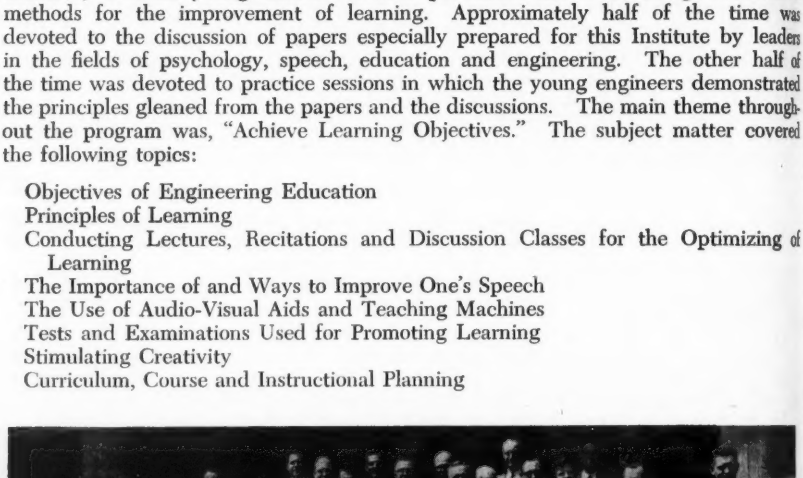
All Students

	Question Number														
Grade	3R	2L	1R	3R	2L	1R	3R	2L	1R	3R	2L	1R	3R	2L	1R
20	10	6	9	22	9	11	53	12	37	21	2	22	16	4	11
19	3	2	4	5	2	10	13	5	1	1		4	10	6	9
18	27	14	36	23	5	14	4	3	6			2	6	5	5
17	8	6	12	7	5	3	2	2	1				5	2	8
16	14	7	7	5	3	2	2			1	1		4		6
15	21	17	23	12	3	9	Med 44	16	28	92	49	47	7	6	9
14	14	4	11	2		3	4	5	5	Med 10	2	3	4	3	5
13	Med 20	Med 10	Med 21	2	1	3	7		6	5	1	4	4	5	7
12	14	3	11	6		7	13	11	21	2			8	4	4
11	9	3	5		1		7	4	3	1			5	3	7
10	22	12	13	14	5	4	27	Med 8	Med 24	42	Med 13	Med 52	14	4	11
9	7	1	8	3		4	5	5	7	1		3	16	6	14
8	12	8	5	12		14	6	7	10	7	1	8	Med 22	Med 13	Med 21
7	11	3	8	Med 4	3	3	1	5	6	3	1	2	21	12	13
6	5	3	7	4	1	5	2	3	2	4	2	5	20	10	17
5	12	4	14	16	12	12	5	6	13	31	32	47	22	16	31
4	2	2	3	15	7	Med 8	3		4	3	1	2	11	4	8
3	2	5	4	15	3	10	2	2	9				10	5	12
2	6	2	8	19	Med 3	19	12	8	7	1			6	4	9
1	1	0	1	2	4	2	3	1	3			1	5	0	5
0	11	4	13	43	49	80	16	13	30	6	11	21	15	4	11

Effective Teaching for Young Engineers

The first two-week Summer Institute on "Effective Teaching for Young Engineering Teachers," sponsored by the ASEE and the ECPD, was held last summer, August 28 to September 9, at Penn State University. The objectives of this Institute were to give training in the fundamental principles and the use of effective teaching methods, to orient young teachers to their profession and to encourage research in methods for the improvement of learning. Approximately half of the time was devoted to the discussion of papers especially prepared for this Institute by leaders in the fields of psychology, speech, education and engineering. The other half of the time was devoted to practice sessions in which the young engineers demonstrated the principles gleaned from the papers and the discussions. The main theme throughout the program was, "Achieve Learning Objectives." The subject matter covered the following topics:

Objectives of Engineering Education
Principles of Learning
Conducting Lectures, Recitations and Discussion Classes for the Optimizing of Learning
The Importance of and Ways to Improve One's Speech
The Use of Audio-Visual Aids and Teaching Machines
Tests and Examinations Used for Promoting Learning
Stimulating Creativity
Curriculum, Course and Instructional Planning



Among the 59 educators and engineers who participated in the first Summer Institute on Effective Teaching for Young Engineers were the group pictured here: Left to right, front row—McDaniel, Mississippi State; Gilbert, Univ. of Cincinnati; Forman, Univ. of Kansas; Flammer, Utah State; Rubin, George Washington Univ.; Grogan, Worcester Polytech.; Nicholson, Univ. of New Hampshire; Kapner, Rensselaer Polytech.; Merrill, Marquette Univ.; Roberts, Missouri School of Mines. Second row—Pritchett, Oregon State; Smith, Auburn Univ.; Eppes, Univ. of Texas; Reemsnyder, Lehigh Univ.; Zuspan, Drexel Institute; Michaels, Kansas State; Moore, Washington State; Fletcher, Univ. of Idaho; Jacobs, Georgia Tech.; Knott, Univ. of Colorado; Bender, Virginia Polytech. Third row—Landis, Univ. of Alabama; Fisher, Princeton Univ.; McCausland, Univ. of Toronto; Hoenig, Univ. of Arizona; Golde, Univ. of Washington; Rodriguez, Cornell; Moy, Univ. of Wisconsin; Woodruff, Michigan State Univ.; Lagerstrom, Iowa State Univ.; Poage, Oklahoma State Univ. Fourth row—Harman, Stanford Univ.; Wandmacher, Univ. of Cincinnati; Giordano, Brooklyn Polytech.; Brass, U.C.L.A.; Lancaster, Penn State; Gaylord, Univ. of Illinois; Rising, Univ. of Massachusetts. Fifth row—Reich, Penn State; Wiksell, Louisiana State; Foecke, Notre Dame Univ.; Gagne, Princeton Univ.; Kraybill, Duke Univ.; Tyler, Center of Advanced Studies, Calif.; Stavely, Penn State; Hatch, U. S. Dept. of Education; Lebold, Purdue Univ.; Carpenter, Penn State.

Evaluation of Instruction
The Development of Professional Consciousness

Twenty-five YETs (men with 1 to 3 years of teaching experience), and ten METs (men with over ten years' teaching experience), participated in the program. In addition to these 35 persons, who were in attendance the entire 2 weeks, 14 other engineers and 10 other education specialists helped to present the program and were there for a day or more. Thus, there was participation, in some form or other, from 50 colleges of engineering and universities. There was at least one participant from each ASEE section of the U. S. and Canada. The picture on page 434 of this issue of the JOURNAL shows the persons present on Wednesday, August 31.

The program was well received by all participants. Consequently, the Society is cooperating with the plans for a similar institute next summer of about twice the size of the previous one. The 1960 project was financed by The Ford Foundation and was directed by Otis E. Lancaster, Westinghouse Professor of Education at Penn State.

SECOND SUMMER INSTITUTE ON EFFECTIVE TEACHING

The Ford Foundation has made a grant for a second and larger Summer Institute on Effective Teaching for Engineers.

This institute and its predecessor are unique in being devoted to principles of learning and their application to the teaching of engineering subjects. The specific objectives are: (1) training in the fundamental principles of learning and use of effective teaching methods, (2) orientation of young teachers to their profession as educators, (3) encouragement of research in methods for the improvement of learning.

This project will be conducted by the Pennsylvania State University, with the cooperation of ASEE and Engineers' Council for Professional Development at State College, Pennsylvania, August 28 to September 9, 1961.

Selection of Candidates: The Institute will be limited to 70 participants. These will include 40 to 50 young engineering teachers under 36 years of age, with the equivalent of 1 to 3 years college-level teaching experience; and 20 to 30 institutional representatives with 10 or more years' teaching experience. The latter will be selected with the understanding that they will endeavor to conduct programs of similar intent and content for young engineering teachers in their local areas. The principal criteria for the selection of young teachers will be demonstrated ability and a desire to advance in the teaching profession.

Remuneration: All expenses for campus living (housing and meals) and the round trip to and from permanent address will be paid. In addition, each participant will receive a tax-free grant of $150.

Application: Application blanks may be obtained from the deans of engineering colleges. To guarantee consideration, all completed forms must be mailed by March 7. Applicants will be notified of their status by April 10.

For additional details, write: Otis E. Lancaster, Westinghouse Professor of Engineering Education, 101 Hammond Building, The Pennsylvania State University, University Park, Pennsylvania.

Cooperative Education—Evaluated

EDWARD H. LYONS AND DONALD C. HUNT

College of Engineering
University of Detroit

In May 1957 the Thomas Alva Edison Foundation sponsored a meeting in Dayton, Ohio, on "Cooperative Education and the Impending Educational Crisis." This conference was attended by representatives of over 80 colleges and universities and personnel of nearly 400 firms employing cooperative students. The purpose of the conference was to look at the existing working models of cooperative education. One of the findings was that no documentation of the value of cooperative education had ever been made.

In October 1957 Charles F. Kettering, following correspondence with Mr. Donald C. Hunt, Director of Coordination and Placement at the University of Detroit, invited the representatives of several cooperative institutions to another meeting at Glenmont in New Jersey. Here it was decided to seek foundation support for a study to provide this documentation, and Dr. Clarence H. Faust, President of the Fund for the Advancement of Education, became interested in the matter. He sponsored a meeting in Chicago in March 1958—out of which came a generous grant from the Fund for a systematic study of cooperative education and its implications for the national welfare. The work was done under the general auspices of the Thomas Alva Edison Foundation and was supervised by a special committee on the Study of Cooperative Education. At its first gathering, in Detroit in July 1958, the Committee elected Dr. Ralph W. Tyler as its Chairman, appointed Dr. James W. Wilson as Executive Director of the Study, and Edward H. Lyons as Associate Director.

A summary of major findings of the recent Study of Cooperative Education conducted under a grant from the Fund for The Advancement of Education, and based on presentations given at the Annual Meeting of ASEE at Purdue University in June 1960. Members of the Study Committee were: Mr. Walker Cisler, President, Detroit Edison Company and President, Thomas Alva Edison Foundation; Dr. Ralph W. Tyler, Director, Center for Advanced Study in the Behavioral Sciences; Dr. William C. Fels, President, Bennington College; Dr. Samuel B. Gould, Chancellor, University of California at Santa Barbara; Dr. Edwin D. Harrison, President, Georgia Institute of Technology; Mr. Donald C. Hunt, Director, Coordination and Placement, University of Detroit; Dr. Walter C. Langsam, President, University of Cincinnati; Mr. Kenneth A. Meade, Director, Educational Relations, General Motors Corporation; Mr. Kenneth G. Patrick, Vice President, Corporate Relations, Council for Financial Aid to Education; Mr. George E. Probst, Executive Director, Thomas Alva Edison Foundation; Dr. Thomas G. Pullen, Jr., State Superintendent of Schools, Maryland State Department of Education; Dr. O. Meredith Wilson, President, University of Minnesota; Dr. James Wilson, Dean of College of General Studies, Rochester Institute of Technology; Mr. Edward H. Lyons, Industrial Coordinator, University of Detroit.

Scope of the Study

Because of the current diversity of patterns, the Committee adopted the following broad definition as a basis for its study: "The cooperative plan of education will be defined as that educational plan which integrates classroom experiences and practical work experience in

industrial, business, government, or service-type work situations. The work experience constitutes a regular and essential element in the educational process and some minimum amount of work experience and minimum standards of performance are included in the requirements of the institution for a degree. In addition, there must be liaison between the administration of the institution and the employing firm. The essential criteria, as used in this Study, are that the work experience be considered an integral part of the educational process, and that the institution take a definite responsibility for this integration."

The primary objectives of the Study were:

1. To conduct an objective, candid, and penetrating evaluation of the cooperative plan of education as it pertains to institutions of the United States which grant the baccalaureate degree.
2. To make recommendations in the area of educational policy and experimentation and needs for further research, based upon, but not restricted to, the findings of the evaluation.
3. To disseminate the findings of the evaluation and the subsequent Study Committee reflections upon these findings in regard to higher education.

The basic plan for attaining the objectives of the investigation was: (1) to select a representative sample from the population of cooperative institutions and a sample of non-cooperative institutions which, in so far as possible, would be comparable to those cooperative institutions selected; (2) from these institutions, to collect data from a sample of students, graduates, faculty, and administrators which would be relevant to the purposes of the investigation; and (3) to collect relevant information from the sample of firms which employ cooperative students.

Each of the participating institutions was asked to administer to a random sample of freshman and senior students in the selected programs a questionnaire constructed for the purpose of this investigation, entitled *College Experiences Questionnaire*. This questionnaire asked students about their family background, some of their pre-college experiences, their academic behavior, their social and extra-curricular activities, their goals, the financial aspects of their college attendance, and their work experience. An additional section of the questionnaire, for cooperative students only, asked about their experiences in and attitudes toward their cooperative programs. This *College Experiences Questionnaire* was completed by 2,247 freshman and senior students.

In addition, those institutions in the basic sample administered to the same freshman and senior students a psychological scale called the *Activities Index*. A total of 1,611 students completed this instrument which provided a picture of the psychological needs of students. The *Activities Index* consisted of 300 statements for each of which the student indicated whether it described an activity or event he would like, enjoy, or find more pleasant than unpleasant, or whether it described an activity or event that he would dislike, reject, or find more unpleasant than pleasant. Information relevant to 30 different need variables was provided by this scale.

Finally, the same senior students and a group of junior students from each of the colleges in the basic sample were administered a third instrument, the *College Characteristics Index*. The C.C.I. provided information about students' perceptions of their college environment—the characteristic pressures and expectations. Like the *Activities Index*, the C.C.I. provided this student-eyed picture of the institutions for 30 different psychological variables. A total of 1,344 completed College Indexes were obtained.

A mailed questionnaire, called the *College Graduate Experiences Questionnaire*, was designed for this investigation. Like the *College Experiences Questionnaire*, it asked graduates about their family background and about their college experiences. The majority of items, however, dealt with their educational, occupational, and civic experiences since ob-

taining the baccalaureate degree. Again, a special section for cooperative experience was provided for graduates of cooperative programs. A total of 4,012 questionnaires was mailed to graduates. With one follow-up card, 2,476 or 61.7% usable questionnaires were returned. This response was one of the emotional high points of the investigation, particularly in view of the fact that the questionnaire was 34 pages long. The respondents were from the classes of 1939, 1950, 1953, 1955, and 1958.

Interviews were conducted by the National Opinion Research Center. From the pool of names drawn as the second sample of graduates from all institutions constituting the basic sample, NORC drew the final interview sample. Also, NORC developed the interview schedule from a set of specifications provided them by the staff of the Study. The interview schedule, to a large extent, paralleled the mailed questionnaire, but, in addition, asked numerous open-ended questions, the answers to which were recorded verbatim. Interviews were conducted with 486 graduates. The average length of time for each interview was one hour and fifteen minutes.

The great bulk of data for the research came from these sources. In addition, however, admissions data were provided for those freshman and senior students in the basic sample; results of Graduate Record Examinations were obtained from a portion of the senior students sample; questionnaire data were obtained from 163 faculty members who teach cooperative students; interview and questionnaire data were obtained from 30 industrial firms employing cooperative students. All of the information was transferred to 18,000 IBM cards which were processed 70 times giving 1,260,000 items of data.

Some Interesting Results

Cooperative students were asked about their reasons for taking a cooperative program in college, and a majority gave multiple reasons for their choice. Over 70% of the students indicated the following as among the reasons for selecting a cooperative program:

1. They desired vocational training. (78%)
2. They wanted to apply principles and concepts to concrete situations. (76%)
3. Financial assistance was necessary. (77%)
4. Cooperative programs offer a practical education. (77%)
5. They wanted to learn what the world of work is like. (73%).

Students were asked to indicate which were the two most important reasons for taking a cooperative program and the only reason reported as "most important" by any significant proportion was "financial assistance." This response was given by 39% of the students and no other single reason was reported by as much as 15% of the students.

The cooperative students' evaluation of their education found them supporting the claimed advantages of cooperative education, with their most enthusiastic support given to the advantages of "learning what employers expect in the world of work" and "receiving vocational training."

Cooperative education has always been presented as an educational method which enabled students from the lower socio-economic strata and from families of a lower educational level to gain a college education. The data very clearly support this contention. The percentage of all students surveyed fell into each of the five status levels as follows: (4% not reported)

Upper — 5%
Upper Middle—32%
Lower Middle—29%
Upper Lower —25%
Lower Lower — 5%

The data revealed that a significantly larger proportion of the non-cooperative students come from the two upper strata and that a larger proportion of cooperative students come from the two lower strata. The Study also supported the contention that there is a greater history of higher education among the families of non-cooperative students. This is true for fathers, mothers, brothers, and sisters, and other close relatives. In addition,

the results showed that a larger number of cooperative students come from families where the parents have less than a high school education.

In evaluating the differences in intellectual ability between students of cooperative and non-cooperative programs, the College Entrance Examination Board Tests, the Psychological Examination of the American Council on Education, the Graduate Record Examination, the average grade of the last year in high school, and high school honors were compared. In general, the results showed the cooperative student to be about the same as, or slightly higher than, the non-cooperative student in scholastic ability and intelligence.

Much of the criticism of cooperative education has been centered around the lack of motivation for school learning, and on the other hand, one of the important advantages cited by educators in the field is that students are more motivated as a result of their industrial training. In order to determine what differences existed, if any, the following items were assessed: interest in courses outside of major, unassigned reading for courses within and outside of major, out-of-class study, kinds and amount of reading, intellectual activity, and graduate study. The data indicated that virtually no differences exist between cooperative and non-cooperative students. However, if consideration is given to the socio-economic strata of the cooperative student, wherein environmental influence toward learning could be low, it might be hypothesized that the cooperative student receives *added motivation* to the extent that he is able to compare favorably with his upper strata counterpart in the non-cooperative program. This hypothesis is even more applicable to engineering students.

About 35% of all the graduates either attended or are currently attending graduate school, and the percentage was constant for all groups from 1939 through 1958. No significant differences exist between cooperative and non-cooperative graduates who have attended or are attending graduate school. Although more non-cooperative graduates have earned advanced degrees, more cooperative graduates are currently working toward advanced degrees. It might be hypothesized that this is a continuation of the work-study pattern and that many of the cooperative graduates are pursuing graduate work on a part-time basis, and thus are taking longer to obtain the graduate degrees.

It is interesting to note that for both cooperative and non-cooperative graduates, the percentage of those who indicated that they received "just about the right amount" of intellectual activitiy during their undergraduate days increased according to the length of time they had been out of school, with the class of 1939 having the highest percentage response of the three groups in this category. It was found from the student data that significantly more cooperative than non-cooperative seniors expressed satisfaction with the amount of intellectual activity afforded them. In view of this finding and of the graduate results, it might be hypothesized that the work experience provided a reference point for evaluating the amount of intellectual activity desirable for professional competence. The cooperative graduate by virtue of his work obtains this point of reference by the time of graduation. The non-cooperative graduate, it is hypothesized, gained this reference in the years following graduation.

In answer to the question of the amount of practice they had in applying principles and concepts to concrete situations, the proportion of cooperative graduates who indicated that they received "just about the right amount" increased with the number of years out of college, whereas it decreased for the non-cooperative graduates. It was found from the student data that significantly more cooperative seniors than non-cooperative seniors were satisfied with the amount of practice they had received in college. It might be hypothesized that, as the cooperative graduate grows professionally, he becomes more and more appreciative of the opportunity his college days provided him in applying principles to concrete situations. On the other hand, the non-cooperative graduate, as he comes to

find out the importance, in business and industry, of applying principles, becomes more and more dissatisfied with this aspect of his college program.

A comparison of the extracurricular activity of the seniors in the survey showed that 26% more cooperative students held memberships in fraternities or sororities than did the non-cooperative students. In professional societies and interest groups, 9% more cooperative students held memberships.

The Study data clearly indicated that the cooperative students felt they have gained more career information than non-cooperative students, primarily because of the work experience. But even here, a sizable proportion of cooperative students as well as non-cooperative students felt that the amount of career information they have received is insufficient.

Virtually no significant differences exist between cooperative and non-cooperative graduates in terms of job satisfaction, length of time on first job, number of different employers, or results of job changes. In addition, the reasons given for being either satisfied or dissatisfied with their present job showed no difference between cooperative and non-cooperative graduates.

Considerable data were obtained regarding the psychological "needs" of the engineering students and the "press" or environmental influences exerted by the engineering faculties and colleges. The needs of the students and the press of the colleges were then correlated. The most interesting result of this correlation was the very strong press of the institutions for behavior which is precise and orderly and the almost *complete absence* of such need among the engineering students.

Industrial Opinions

One of the principal reasons cited by industrial employers for participation in cooperative education programs is that it provided them with a regular flow of qualified talent. In this respect, it is used as a recruiting and selection device to attract capable personnel with the best potential for specific areas of work in the company.

Another value of the cooperative system observed by employing companies is that it provides a source of valuable assistance in the handling of semi-professional, technician, or aide activities which allow members of the full-time professional staff to concentrate their efforts and talents in creative work for which they are best qualified. A number of such technician work assignments for cooperative students serve as an excellent means for giving them a breadth of knowledge of the company and its operations as well as practical experience with such important things as costs, quality, and meeting schedule deadlines. It helps the individual student to become oriented to company policies, practices, and people. It helps him to learn how to apply theoretical information to practical problems at a time when this knowledge is freshest in his mind, thus assisting in maturing him industrially. The business or industrial organization in which the student is employed serves as a well-equipped laboratory with facilities and staff which no college or university could or should maintain.

Thirty-eight per cent (38%) of the cooperative graduates who responded indicated that they had worked as graduates for an organization which employed them as cooperative students. Significantly more engineering graduates than either business or liberal arts had worked for their cooperative employers. A total of 1,224 engineering graduates were questioned and 546 or 45% had worked for their cooperative employer after graduation.

Industrial and business employers who have had satisfactory results with cooperative students indicate that there are certain responsibilities that the employing organization must assume if the objectives of the program are to be achieved. There should be a high degree of coooperation with the educational institution handling the academic portion of the program in solving problems that may arise in individual student situations. Students should be carefully selected. Every effort should be made to select those who will fit into the organization and have potential to make some contribution to it. Tech-

niques of selection similar to those used in recruiting traditional college graduates and high school students to be trained in apprenticeship and other special programs should be utilized.

One criticism leveled at the cooperative system is that it results in the selection of students not well suited for the jobs to which they are assigned or who are more interested in the job as a source of income rather than a means of furthering their education. When this occurs, problems arise in the administration of the program both on the part of the school and the company. A number of employers suggest that cooperative programs should be considered as honor programs and students be carefully selected by the school for cooperative employment. Institutions that have done this find that it works satisfactorily.

An industrial organization must consider its cooperative student program from a long range standpoint. A successful program cannot be geared to economic conditions that happen to exist at the time new students are being selected. An employment quota of entering students must be determined on the basis of a realistic forecast of personnel needs for four or five years and should be continued in spite of fluctuations in the national economy.

The effects of the recent recession, as reported by the employers of cooperative students, were varied. Half of the respondents indicated that the recent recession had no influence upon their cooperative programs. The remainder indicated that they either reduced the total number of students in the program or had to refrain from taking on any additional new students. One employer terminated the program.

The work program of the student should be carefully planned. The employer and the educational institution should work together in coordinating the program to insure as far as possible that the work experience of each student is integrated with his academic experience and maturity. Work assignments should be selected to conform as nearly as possible with the ability, interests, educational level, and curriculum of the students.

Industry has a growing sophistication about education generally. It might well consider a cooperative education program to be one form of corporate support of education, where the company's stake is definitely long-range in character, but where it is definitely getting something back for its money and interest. Industry has a very real interest today in the better use of educational facilities and resources, and in the more productive and efficient operation of the educational system. It has come to be publicly worried about the rate of dropouts in college, about provisions for gifted students, and about getting into college those high school students who would not otherwise go for economic or counseling reasons. Industry is worried about its taxes, and is beginning to understand that initiative in the private sectors may lessen the load. It is even worried about the curriculum, as it studies the uses it is making of its own college graduates in the workforce.

Utilization of Physical Facilities

Here the purpose was to investigate the degree of efficiency of utilization of the educational facilities of an academic institution operating on the cooperative plan as compared to that of the *same* institution operating on a non-cooperative basis. There are, to be sure, a great variety of scheduling programs in use, and an equally broad variation in the administrative handling of the details of scheduling with respect to the number of periods devoted to academic work on the campus and the number of cycles spent in on-the-job training. There is also variation in both the lengths of the periods and the distribution throughout the instructional program. The purpose here was to consider a few of the more typical cases and to demonstrate analytically the effect upon the optimal utilization of the educational facilities for each scheme of cooperative education in contrast to a typical non-cooperative plan.

Necessary for this analysis are a number of assumptions which are made explicit below:

1. The institution is arbitrarily assumed to have a total on-campus capacity of 1,000 students. This will be the case for both the cooperative and non-cooperative programs.
2. The cooperative program is five years and the non-cooperative program four years.
3. It is assumed that the 1,000 students are equally distributed throughout the years of the program. Cooperative students are equally divided into two groups during the years of alternation.
4. The attrition rates are the same for both cooperative and non-cooperative students; however, it is assumed that the operation is at full capacity at all times.

There are factors such as possible need for increased faculty and staff for year-round operation, more rapid deterioration of facilities used twelve months instead of nine, additional office space needed for an increased faculty, and the inclusion of a separate administrative organization to handle the details unique to the cooperative program which influence the operation of the educational programs. However, because of the wide divergence in methods of handling these factors and the difficulty of assigning numerical values to their effects, these factors are not incorporated in the analysis.

PRODUCTION OF GRADUATES OF COOPERATIVE PROGRAMS ON A 1,000 STUDENT CAMPUS

Number of Years Program Existed	Number of Grads in a Conventional 4-Year Program	Case I 5 of 5 Years are Cooperative		Case II 4 of 5 Years are Cooperative		Case III 3 of 5 Years are Cooperative	
		Number of Grads	Increase Over 4-Year Program	Number of Grads	Increase Over 4-Year Program	Number of Grads	Increase Over 4-Year Program
10	1,750	2,400	37%	2,004	14%	1,716	−2%
20	5,550	8,400	53%	7,014	27%	3,146	9%
50	11,750	18,400	57%	15,364	31%	13,156	12%
α	—	—	60%	—	33%	—	14%

Case 1—Co-op begins at the beginning of the freshman year and continues throughout the five years. Fifty-seven per cent (57%) more graduates at the end of 50 years.

Case 2—Co-op starts during the first year or beginning in the second and continues for the remainder of the five years, or the equivalent. Thirty-one per cent (31%) more graduates at the end of 50 years, but only 15% by the end of 10 years.

Case 3—Co-op starts at the beginning of the third year and continues for three years, or the equivalent. Twelve and one half per cent (12.5%) more graduates at the end of 50 years, but 2% less graduates at the end of 10 years, and only 5% more at the end of 15 years.

At the end of 50 years the practical optimum is reached in all three cases. The number of graduates does not increase more than 1/200 of 1% per year thereafter.

It is clear from the several cases presented that the cooperative plan does offer advantages. They further demonstrate that different organizational schemes of the cooperative plan produce different degrees of efficiency with regard to total numbers of students enrolled and the production of graduates. Varieties of further modifications are also possible.

In any actual operation of a cooperative program all of the theoretical measures of greater efficiency presented here would be smaller. This is so because of such factors as increased staff and faculty required to conduct cooperative programs, more rapid deterioration of plant due to year-round use, etc. Obviously

it is impossible to produce twice the number of graduates through a cooperative program. The advantage is much less from a practical point of view and ranges between limits of 14% and 60% under optimum conditions.

Summary of Values

The results of the Study clearly indicated the following important educational values of the cooperative system:

1. By coordinating work experience with the campus educational program, theory and practice are more closely related and students find greater meaning in their studies.

2. This coordination of work and study increases student motivation. As students see connections between the jobs they hold and the things they are learning on the campus, greater interest in academic work develops.

3. Students in cooperative education develop greater understanding of other people and greater skills in human relations.

4. Cooperative education furnishes students with opportunities for exploring their own abilities in connection with real jobs, and they find a direct means of gaining vocational information and vocational guidance not only in the occupations in which they are employed but in a number of related fields as well.

5. Cooperative education has an important value in making higher education possible and attractive to many young people who would not otherwise go to college. The earnings of the students while on the job have enabled many to attend college who could not finance their education without it.

6. As work programs are planned and developed and as the students rotate from college to work and back to college again, the faculty is better able to keep in touch with business, industry, and some of the professions.

7. Because cooperative education is commonly organized so that half the students are at work while the other half are on the campus, the plan permits more efficient utilization of the college plant and other facilities.

8. A number of business and industrial firms find the cooperative program a means of maintaining a flow of trained personnel. It often provides a means for attracting promising young people into the occupation and serves as an actual testing ground.

9. For the student, cooperative education furnishes contacts useful in later occupational placement, and for many it gives a head start in salary and position.

10. A number of the colleges find cooperative education providing greater recognition by the community of the services the colleges are rendering to it and thus furnishing an additional basis for moral and financial support for the colleges from the community.

11. The review of all the possible disadvantages led to the conclusion that none of them is real when adequate coordination is provided both by the college and the employers and when the employers provide necessary stability to the employment opportunities for students. The values of cooperative education are very significant and the problems are soluble.

Recommendations of the Committee

Deliberations of the Committee led them to identify improvements needed in cooperative programs so that the desired educational values may more adequately be achieved. The Committee also considered possible extensions of work-study programs and the need for more information by colleges and the general public. These considerations represent the substance of the following recommendations:

1. When cooperative education is treated as a basic concept for relating theory to practice in education, and when flexible arrangements and varied procedures are evolved rather than a rigid set of operations, the resulting program is more likely to become a very successful one. It is recommended that imagination be used in developing programs that are appropriate to the conditions and purposes of the individual college.

2. It is recommended that in initiating a plan of cooperative education the fac-

ulty be intimately involved in planning, particularly as it relates to their own teaching, and that after the program is established there be continuous or periodic participation by the faculty in planning and coordinating so that they will have a more adequate understanding of the potential and the problems to guide their own teaching.

3. Primary attention should be given to a close and responsible relationship between the employer and the college in the planning of work experiences, in the selection of students qualified to undertake the job assignments, and in maintaining a relatively stable level of cooperative employment through the fluctuations of the business cycle.

4. A program which increases student motivation, helps the student to find more meaning in his school studies, attracts more able young people into higher education, and enables more of them to go to college should be extended far beyond the relatively small number of colleges now using cooperative education.

5. At present cooperative programs are most often found in engineering and business education. Teaching, social work, and the civil service are three occupations in which there are serious shortages of trained personnel. It seems likely that cooperative programs specifically designed in each case to meet the peculiar needs of the profession would attract additional students and help to improve their educational experience. Exploration and experimentation with cooperative programs in a much wider range of occupational fields are recommended.

6. There are only a few liberal arts colleges employing cooperative education. The findings of this study indicate both the values and the feasibility of cooperative education in colleges of liberal arts, and such programs should be greatly expanded.

7. In extending cooperative education exploration and experimentation with it in post-graduate education are recommended. Most graduate students are now employed part time as a means of financing their study, but the necessities of a job provide no guarantee of certain values of a work experience carefully planned to relate theory and practice. Here is a field for important pioneer work.

8. The Committee was amazed at the lack of information about cooperative education among school and college staffs and students, among parents and employers, and on the part of the public generally. Much more attention needs to be given to informing various groups about the nature and values of cooperative education.

9. There is also need to develop, on the part of secondary school personnel and students, a better understanding of the philosophy underlying cooperative education, the basic assumptions governing the programs and their potential values. This understanding is essential to the intelligent guidance of students who are interested in such a plan of education.

CAPITAL EXPENDITURES SYMPOSIUM

A Summer Symposium on "Planning and Justifying Capital Expenditures" was held at Pittsburgh, Pa., on June 13–14th, 1959. It was sponsored by the Engineering Economy Division of the American Society for Engineering Education and the Engineering Economy Research Committee of the American Institute of Industrial Engineers.

Copies of the papers and discussions may be ordered from THE ENGINEERING ECONOMIST, Stevens Institute of Technology, Hoboken, New Jersey.

The price is $4 for members of ASEE and AIIE, for educators, schools and all libraries, and for those who attended the Symposium; and $10 for others.

Pan-American Exchanges in Engineering, Science, and Agriculture

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Introduction

In these days of unparalleled advances in engineering and science, constant attention must be given to needed improvements in the complex field of engineering education. We look upon the Union Panamericana de Associaciones de Ingenieros as a vital instrument for accomplishing such improvements in all the nations represented. But of great significance, too, is UPADI's opportunity to play an important role in the broader sphere of international relations. The great need is for more and more men and women of the world to travel abroad and meet others whose actions, customs, and traditions may be quite different from their own but whose ultimate aspirations are the same. Such first-hand experience among peoples of different languages, cultures, and philosophies is an important link in the chain of understanding among nations.

This point of view is implicit in all programs of educational exchange. Such programs are sponsored in large numbers by governments, foundations, universities, industrial companies, societies, fraternal organizations, and individuals. The immediate and conspicuous purpose is to provide highly qualified individuals with specialized training not usually available at home. But there is a deeper purpose. All countries recognize the world-wide need for social, economic, educational, and scientific development. To help meet this need many nations annually award thousands of fellowships, scholarships, and grants for study abroad. These serve the dual purpose of promoting international cooperation and of increasing the world's supply of educated manpower.

It is the purpose of this paper to investigate the extent to which the UPADI countries are achieving these objectives. Much background information is needed to accomplish this purpose.

Presented at the First Pan-American Congress on Engineering Education held in Buenos Aires, Argentina, September 12–17, 1960, in connection with the Fifth Convention of Union Panamericana de Associaciones de Ingenieros (UPADI).

Sources and Scope of Information

The authors of this paper restrict themselves primarily to information relating to educational exchange between the United States and the other UPADI countries. Complexities are much too great to go further than this.

It should be made clear, however, that there are excellent sources of information on programs of educational exchange among all the countries of the world that sponsor such programs. One source is a volume of nearly 800 pages, entitled *Study Abroad*, published in 1958 by the United Nations Educational, Scientific and Cultural Organization (UNESCO), Place de Fontenoy, Paris 7e, France. The volume has been appropriately sub-

titled as an *International Handbook on Fellowships, Scholarships and Educational Exchange*. It is, indeed, just that. The publication has been distributed widely among universities and libraries of all the UPADI countries. The book is commended to the attention of all interested members of this Congress. It may be purchased for $3.00 from UNESCO Publication Center, 801 Third Avenue, New York 22, N. Y., U. S. A.

An excellent statistical report on world-wide international exchange is a 48-page booklet, *Open Doors 1959*, published by the Institute of International Education, 1 East 67th Street, New York 21, N. Y., U. S. A. Many other publications on the subject of educational exchange are available in the United States, notably those of the Department of State, Pan American Union, International Cooperation Administration, Organization of American States, American Council on Education, National Academy of Sciences, National Science Foundation, International Association for the Exchange of Students for Technical Experience, and many others. All these have been most helpful to the authors of this paper. But the principal sources of their material were *Study Abroad* and *Open Doors 1959*.

For the material gathered from these sources the authors hereby express their deep gratitude, especially to UNESCO and the Institute of International Education and to all who assisted in the collection and presentation of the vast amount of world-wide information contained in both books. Such statistical information as related to educational exchange between the United States and the UPADI countries in the specific fields of agriculture, engineering, and the physical and natural sciences was sorted out, assembled, totaled, and analyzed. The results are presented in what follows.

Foreign Citizens in the United States

The Institute of International Education compiled its first annual report on international educational exchange in 1955. Since that time there has been a steady increase in the number of foreign citizens who have visited the United States on educational assignments. Comparisons are shown in Table 1.

TABLE 1

FOREIGN CITIZENS IN U. S. COLLEGES, UNIVERSITIES, HOSPITALS

	1954–1955	1958–1959	Per Cent Increase
Students	34,232	47,245	38%
Physicians	5,036	8,392	67%
Visiting faculty	635	1,937	205%
Total	39,903	57,574	44%

Ratio of Foreign to All Students

Pertinent to the topic of international exchange in higher education is the ratio of the number of foreign students to total enrollment in the world at large. Although the latest information on this point was not available to the authors, *Study Abroad* gives the following statistics for 60 countries for the academic year 1956–1957. It has been estimated that the world total of foreign students in higher education during 1956–1957 was about 165,000. The figure given in Table 2 is 92% of this total.

TABLE 2

FOREIGN STUDENTS IN HIGHER EDUCATION IN 60 COUNTRIES IN 1956–1957

Total Enrollment	Foreign Students	Ratio (%) Foreign to Total
7,793,280	151,459	1.9%

TABLE 3

FOREIGN STUDENTS IN 9 UPADI COUNTRIES (1956–1957) COUNTED IN A SURVEY OF 60 COUNTRIES

UPADI Country	Total Enrollment	Foreign Students	Ratio (%) Foreign to Total
Argentina	142,522	11,794	8.3%
Canada	72,745	4,275	5.9%
Chile	11,211	166	1.5%
Colombia	14,673	326	2.2%
Ecuador	6,216	270	4.3%
Panama	2,563	121	4.7%
Paraguay	3,484	64	1.8%
Puerto Rico	18,680	134	0.7%
United States	2,918,212	40,666	1.4%

Corresponding figures for those UPADI countries included in Table 2 are presented in Table 3.

Unfortunately, less than half the UPADI countries were included in this survey. But, of those that were, Argentina led the list in the ratio of its foreign students to total enrollment. This ratio of 8.3% is far in excess of the world average of 1.9%. It is significant, however, that Mexico reported 1,123 students from the United States in 1956–1957, and 952 in 1957–1958. Of the latter number, 841 attended Mexico City College.

Students from the United States in Other UPADI Countries, 1957–1958

Open Doors 1959 gives a world-wide list of institutions of higher education that reported the number of students from the United States who registered with them during the year 1957–1958. Table 4 presents the totals reported by 12 UPADI countries, Jamaica, and Trinidad. Figures for 1958–1959 were not available at the time of this writing.

If the number, 1,666, listed in Table 4 for Canada is deducted from the total, we see that 1,049 U. S. students studied in Latin America in 1957–1958. It is regrettable that this is less than half the number reported by Latin American countries in 1956–1957. Statistics relating to this situation are given in Table 5.

Thus in 1957–1958 there was a significant decrease in the number of U. S. students who studied abroad; and 58% of this decrease was attributable to the sharp decline in the number of students who went to Latin America. Through expansion of some of its exchange programs the United States is making efforts to reverse this regrettable decline.

TABLE 4

FOREIGN STUDENTS IN ALL FIELDS FROM THE UNITED STATES REPORTED BY UPADI COUNTRIES, JAMAICA, AND TRINIDAD IN 1957–1958

Argentina	4	Cuba	7	Mexico	952
Canada	1,666	Dominican Republic	19	Panama	7
Chile	1	Ecuador	14	Paraguay	1
Colombia	31	Guatemala	2	Trinidad	2
Costa Rica	7	Jamaica	2	Total	2,715

TABLE 5

U. S. STUDENTS ABROAD

	In All Countries	In Latin America	Ratio (%) L.A. to All
1956–1957	12,285	2,570	20%
1957–1958	10,213	1,049	10%
Decrease	2,632	1,521	58%

Foreign Students from UPADI Countries in the United States, 1958–1959

Table 6 shows the number of nationals of UPADI countries who studied agriculture, engineering, and the physical and natural sciences in the United States during the year 1958–1959.

Thus about one-fourth of the students who went to the United States from the UPADI countries in 1958–1959 enrolled in engineering. This ratio surpassed that of any other field of study. The combined enrollment in engineering and science accounted for more than one-third of the total. The remaining two-thirds were distributed over the fields of medicine, education, social science, business administration, agriculture, and the humanities. The greatest concentrations in engineering occurred in the fields of mechanical, civil, and electrical engineering.

It will be of interest to compare the number of students that went to the United States from UPADI countries in 1958–1959 with the number from all countries of the world. This information is presented in Table 7.

Thus, of all the foreign students in the United States during 1958–1959, about 30% came from UPADI countries.

Because of a deep desire among students everywhere for advanced study and research, it will be of interest to examine breakdowns of the totals in Table 6 between graduate and undergraduate students from the UPADI countries. Also of interest is the question of their

TABLE 6

STUDENTS FROM UPADI COUNTRIES IN THE UNITED STATES, 1958–1959

Home Country	Agriculture	Engineering	Sciences	Other*	Total
Argentina	6	49	32	175	262
Bolivia	12	61	16	94	183
Brazil	10	134	59	357	560
Canada	76	911	754	3,691	5,432
Chile	23	56	41	167	287
Colombia	54	276	51	334	715
Costa Rica	17	42	16	125	200
Cuba	45	697	72	831	1,645
Dominican Republic	6	27	2	46	81
Ecuador	14	63	9	90	176
El Salvador	28	58	18	141	245
Guatemala	24	62	20	159	265
Haiti	3	19	7	89	118
Honduras	12	29	4	95	140
Mexico	70	246	104	952	1,372
West Indies	1	25	11	26	63
Panama	38	89	47	383	557
Paraguay	1	2	4	38	45
Peru	32	114	34	211	391
Uruguay	2	7	4	30	43
Venezuela	39	482	92	544	1,157
Total	513	3,449	1,397	8,578	13,937
Per Cent	3.7%	24.7%	10.0%	61.6%	100%

* Medicine, education, social science, business administration, and the humanities.

financial support. This information is displayed in Table 8.

If account is taken of the unknown factors in Table 8, we may estimate that about two-thirds of the 13,937 students who went to the United States from the UPADI countries for higher education in 1958–1959 were self-supporting, and perhaps more than one-fourth of them were engaged in graduate work.

TABLE 7

FOREIGN STUDENTS IN THE UNITED STATES IN 1958–1959

Academic Status	To U.S.A. from All Countries	To U.S.A. from UPADI Countries	Ratio (%) UPADI to All
Undergraduate	24,349	9,226	37.9%
Graduate	16,793	3,059	18.1%
Special or Unknown	6,103	1,652	27.0%
Total	47,245	13,937	29.5%

Exchange of Faculty

Statistics on the exchange of faculty members between the United States and the other UPADI countries are presented in Table 9.

From Table 9 we see that, in the fields of agriculture, engineering, and science, a total of 81 faculty members went from the UPADI countries to the United States in 1958–1959 and 51 went from the United States to the UPADI countries. These figures represent 36.8% and 34.5% of the respective totals of 220 to the United States and 148 to the UPADI countries. Thus, about two-thirds of the total number exchanged in each of the two directions were engaged in the fields of medicine, education, social science, business administration, and the humanities.

Table 10 compares the exchange of faculty members between the United States and the UPADI countries with that between the United States and the rest of the world.

Thus, of all the faculty members that went to the United States in 1958–1959 from the world at large, about one-ninth left UPADI countries; and of all those who left the United States, about one-twelfth went to UPADI countries. It is believed that these ratios should be substantially increased either through greater utilization of existing programs of educational exchange or possibly through the expansion thereof.

Private Organizations and Agencies in the United States Offering Exchange of Persons with UPADI Countries

Many organizations and agencies promote the exchange of persons between the United States and other countries of the world. Appendix 1 of this paper lists those private organizations and agencies which, in 1958–1959, sponsored and financed scholarships, fellowships, and grants for the exchange of persons between the United States and Latin America in the fields of agriculture, engineering, and the physical and natural sciences. As indicated in Table 8, these awards provided financial assistance to some 2,300 students that went to the United States from Latin America during that year. Information was not immediately available to the authors on the private organizations and agencies that sponsored over 1,700 students from Canada.

The large majority of the 13,937 students from Canada and Latin America that studied in the United States during the year 1958–1959 were self-supporting, and an unknown number made their own independent arrangements for study. Appendix 2 lists 86 colleges and universities of the United States, each of which reported 100 or more foreign students in attendance during that year.

TABLE 8

FINANCIAL SUPPORT AND ACADEMIC STATUS OF FOREIGN STUDENTS FROM UPADI COUNTRIES IN THE UNITED STATES DURING 1958–1959

Home Country	Financial Support			Academic Status			
	U. S. or Foreign Gov't. or Private	Self	Unknown	Undergrad.	Grad.	Special or Unknown	Total
Argentina	116	82	64	103	108	51	262
Bolivia	78	71	34	110	38	35	183
Brazil	300	163	97	235	206	119	560
Canada	1,736	2,890	806	3,389	1,754	289	5,432
Chile	176	63	48	88	113	86	287
Colombia	231	380	104	502	136	77	715
Costa Rica	57	114	29	141	31	28	200
Cuba	166	1,271	208	1,436	86	123	1,645
Dominican Republic	17	54	10	66	6	9	81
Ecuador	59	91	26	117	33	26	176
El Salvador	56	168	21	186	14	45	245
Guatemala	58	179	28	205	26	34	265
Haiti	34	65	19	83	23	12	118
Honduras	28	99	13	107	11	22	140
Mexico	314	569	489	755	192	425	1,372
West Indies	32	21	10	57	4	2	63
Panama	155	339	63	462	65	30	557
Paraguay	36	3	6	12	15	18	45
Peru	98	216	77	287	68	36	391
Uruguay	18	12	13	17	18	8	43
Venezuela	328	676	153	868	112	177	1,157
Total	4,093	7,526	2,318	9,226	3,059	1,652	13,937
Ratio (%)	29.4%	54.0%	16.6%	66.2%	22.0%	11.8%	100%

TABLE 9

NUMBERS OF FACULTY EXCHANGED BETWEEN THE UNITED STATES AND OTHER UPADI COUNTRIES, 1958–1959

Country	Agriculture		Engineering		Natural and Physical Sciences		Totals*	
	To U.S.A.	From U.S.A.	To U.S.A.	From U.S.A.	To U.S.A.	From U.S.A.	To U.S.A.	From U.S.A.
Argentina	—	—	—	—	8	—	27	4
Bolivia	—	—	2	1	—	—	3	7
Brazil	—	—	1	2	10	3	19	20
Canada	2	2	5	1	33	4	102	11
Chile	—	2	3	—	2	2	10	14
Colombia	—	8	—	—	1	2	12	13
Costa Rica	—	—	—	—	—	—	—	—
Cuba	—	—	—	—	1	—	9	—
Dominican Republic	—	—	—	—	—	—	1	—
Ecuador	—	—	—	—	—	—	1	3
El Salvador	—	1	—	—	—	—	1	2
Guatemala	2	1	—	—	—	—	3	5
Haiti	—	—	—	—	1	—	2	1
Honduras	—	—	—	—	—	1	—	1
Mexico	—	1	2	1	4	6	20	33
West Indies	—	—	—	—	—	—	—	—
Panama	—	—	1	—	—	1	3	4
Paraguay	—	—	—	—	—	—	—	2
Peru	—	2	1	—	1	5	5	17
Uruguay	—	—	—	—	—	—	1	—
Venezuela	—	1	1	1	—	1	1	3
Various	—	—	—	—	—	2	—	8
Totals (To U.S.A.)	4		16		61		220	
Per Cent	1.8%		7.3%		27.7%		100%	
Totals (From U.S.A.)		18		6		27		148
Per Cent		12.2%		4.1%		18.2%		100%

* The totals in the last column relate to exchange in all areas, including (besides agriculture, engineering, and science) medicine, education, social science, business administration, and the humanities.

Persons interested in the specific details of exchange programs sponsored by private organizations, agencies, and the colleges and universities of various countries, particularly with reference to the number, monetary value, duration, grant conditions, etc., of the scholarships and fellowships awarded under them, or to the countries and fields of education to which they apply, are referred to *Study Abroad.*

TABLE 10

FACULTY EXCHANGE BETWEEN THE UNITED STATES AND OTHER COUNTRIES IN 1958–1959

	From All Countries	From UPADI Countries	Ratio (%) UPADI to All
To U.S.A.	1,937	220	11.2%
	To All Countries	To UPADI Countries	
From U.S.A.	1,842	148	8.1%

International Educational Exchange Service, Department of State, United States Government

The United States Government, through the International Educational Exchange Service of the Department of State, sponsors the exchange of persons between the United States and other countries of the world under the Fulbright Act, the

Smith-Mundt Act, and an Act for Cooperation with the Other American Republics. The authorization for cultural exchange among most of the American Republics is provided under the Inter-American Cultural Convention.

The Fulbright Act currently embraces exchange between the United States and the UPADI countries of Argentina, Brazil, Chile, Colombia, Ecuador, and Peru. Formerly it provided only for cultural exchange but now it includes foreign aid in the form of technical assistance. The Act normally provides transportation for Latin Americans who are sent to the United States, and transportation plus maintenance for U. S. appointees who are sent to Latin America. More apply for Fulbright grants than can be accepted, in the ratio of about 10 to 1. It is, nevertheless, difficult to meet the requests of some of the underdeveloped countries for technical assistance under the Fulbright Act. A case in point is a request from the United Arab Republic for 200 appointees, including 60 engineers, from the United States.

The Smith-Mundt Act provides for the exchange of persons between the United States and Costa Rica, Cuba, Guatemala, Haiti, Mexico, Nicaragua, Panama, Uruguay, and Venezuela. These Latin American countries are not covered by the Fulbright Act. Grants under the Smith-Mundt Act may provide tuition, maintenance, and transportation for Latin American and U. S. appointees.

Under the Inter-American Cultural Convention, U. S. funds provide maintenance in the United States for Latin Americans, and the Latin American Governments provide grants toward maintenance for U. S. students in Latin America. The home government of the appointee usually covers transportation costs.

Agencies which assist the Department of State in the administration of the International Educational Exchange Program are:

Conference Board of Associated Research Councils (advanced research and lecturing)
Institute of International Education (graduate study)
U. S. Office of Education, Department of Health, Education and Welfare (teaching at elementary and secondary school levels, and junior college level)

Grants authorized under the International Educational Exchange Service are usually for one year and for university study, advanced research, teaching, and university lecturing. Short-term grants are also available to Latin Americans for consultation, observation, and practical training. From July, 1957, to June, 1958, there were 521 grants to Latin Americans for study in the United States and 124 to U. S. appointees for study in Latin America. From July to December, 1958, there were 215 grants to Latin Americans for study in the United States or Puerto Rico. All those 860 grants were made in programs in which the field of study was unrestricted. Some of the universities of the United States in which Latin American students were enrolled in these programs are:

Fordham University
Indiana University
Massachusetts Institute of Technology
New York University
Rutgers University
University of California at Los Angeles
University of Florida
University of Kansas
University of Michigan
University of Puerto Rico
University of Texas
University of Wisconsin

International Cooperation Administration, Department of State, United States Government

The United States Government, through the International Cooperation Administration of the Department of State, provides, upon request, a consulting service for the improvement of educational programs in various countries of the world. ICA programs in Latin America are implemented in two ways:

1. Through direct operation and supervision by an ICA-employed staff.
2. By a university of the United States under contract with the ICA.

Under both programs the service may include such features as the training of teachers in modern techniques, the development of more effective instructional methods and materials, or curriculum revisions to better suit the changing needs of the country served. Latin Americans may be sent to the United States, or to other countries with a team of U. S. specialists, for study and observation lasting from several weeks to a year or more. Practically all participants are given training abroad in the field of higher education. During the year which ended June 30, 1959, over 1,550 Latin American participants were sent to the United States or Puerto Rico for training, study and observation in the fields of agriculture, atomic energy, community development, education, health, housing, industry, labor, public administration, public safety, transportation, and others. Still another 72 Latin American participants pursued similar training in Latin American countries other than their own.

Following is a tabular summary of ICA contracts in operation in Latin America on September 30, 1959, in fields relating to engineering and agriculture:

Host Country	Host Institution	U. S. University	Field
Brazil	Rural University of State of Minas Gerais	Purdue University	Agriculture
Chile	Universidad Técnica de Santa Maria	University of Pittsburgh	Engineering Research
Chile	Universidad Técnica de Estado	University of Pittsburgh	Industrial training
Chile	University of Chile	Leland Stanford Junior University	Mining, minerals
Costa Rica	Ministry of Agriculture and Industries	University of Florida	Agriculture
Guatemala	University of San Carlos	University of Kentucky	Agriculture
Mexico	El Olivar School	University of Michigan	Vocational education
Peru	National School of Engineering of Peru	University of North Carolina	Sanitary engineering
Peru	Programa Cooperativo de Experimentacion Agropecuaria	State College of Agriculture and Engineering, University of North Carolina	Agriculture
Peru	National School of Engineering of Peru	State College of Agriculture and Engineering, University of North Carolina	Textile engineering

Operating simultaneously with the 9 ICA contracts listed were 11 more in fields other than engineering and agriculture.

Technical Assistance Services of the Organization of American States (OAS)

The United States Government participates in the technical assistance services of the Organization of American States when requested by the Secretary General of OAS through the Inter-American Economic and Social Council. Such services are established by formal agreement between the Secretary General and the requesting government, and are provided by technical experts of the General Secretariat of OAS or by experts especially engaged for that purpose. When practicable, the United States Govern-

ment furnishes assistance to the extent that resources are available, with due attention to those fields included in the current work program of the Pan American Union.

The General Secretariat pays the salaries of the technical experts on its own staff. The salaries of other experts are paid in accordance with the terms of a covering agreement. International transportation costs are defrayed from OAS funds, but the government that receives direct technical assistance defrays other expenses of the mission, including travel in the country, as well as per diem allowances for members of the mission and other costs of the services required to carry out the assignment.

The above information was released to Latin American members of the Organization of American States on April 22, 1959, in a brochure entitled *OEA Servicios de Asistencia Tecnica Directa.*

During the year 1959–1960 the Organization of American States, operating through the Pan American Union, awarded 170 inter-American exchange fellowships and scholarships to residents of OAS member states for study in any chosen field for periods of 3 months to 2 years. An additional 75 awards were made to Latin Americans for studies in Venezuela and Mexico in the field of education. Expectations are that the number of OAS fellowships for study in unrestricted fields will be increased to 500 eventually.

IAESTE

The International Association for the Exchange of Students for Technical Experience (IAESTE) is an international, non-profit, non-governmental organization whose aims are: (a) to train advanced university students of engineering and the sciences in the industrial techniques of other nations, and (b) to build a foundation for international understanding and goodwill among these potential leaders and the host countries.

IAESTE was founded in Western Europe in 1948 by universities and industries of 9 European countries. IAESTE today has 26 member countries, including the United States and Canada. Nearly 3,000 companies in these countries are providing training for over 6,000 visiting students from member countries.

This exchange program is reciprocal in nature. For each student a country wishes to sponsor for training in an IAESTE member country, it in turn must make a similar training position available to a foreign IAESTE student-trainee. The trainee must cover his own traveling expenses. He receives a maintenance allowance from the firm with which he trains to cover his daily living expenses. Periods of training are usually from 8 weeks to 6 months and usually occur during the student's vacation period.

In order to participate in this exchange, a committee responsible for the efficient administration of the program must be established by the country wishing to join the association. The committee must have the representation of industrial, university and student groups. Countries wishing to participate in this worthwhile exchange should apply to:

General Secretary, IAESTE
Mr. R. A. Beijer
Box 5196
Stockholm 5, Sweden.

The importance of practical training in education is well recognized by all countries. It should be noted that to date no Latin American country is a member of IAESTE, which has been established to arrange for practical training on an international level. IAESTE has stated that it greatly welcomes Latin American participation.

Private Industrial Exchange

Another type of exchange program for technical and educational experience which is gaining considerable attention, though rarely mentioned in official publications on international educational exchange, is of a private industrial nature. A growing number of companies with foreign subsidiaries send promising young employees or capable prospective employees from one country to another for education and industrial training in prep-

aration for subsequent work with the company at home or abroad. For example, Armco International, an affiliate of Armco Steel Corporation, Middletown, Ohio, U. S. A., annually sends a foreign student to the University of Cincinnati for a five-year cooperative degree program in engineering. In addition to receiving 123 weeks of academic work the student is employed after the first year for 96 weeks in an industrial training program in the steel mill and offices of the company's Middletown plant. For this work, which alternates bi-monthly with academic periods, the student receives wages at the going rate, in addition to a scholarship stipend of $1,600 for the first year. Three Armco International Scholarship holders are now enrolled in engineering at the University of Cincinnati, two from Uruguay and one from Cuba. All of them are expected to return to their native lands after graduation for service with Armco. The plan is commended to all companies with foreign affiliates or subsidiaries.

Inter-American Exchange Programs

1. *United Nations Technical Assistance Programs*

Under the Technical Assistance Programs of the United Nations a number of fellowships and scholarships of varying amounts have been made available to nationals of Latin American countries that request assistance in carrying out projects of economic and social development. Experts of many countries, including the United States, are sent on missions abroad to render technical assistance in these programs. Following is a tabular summary of those fellowships authorized by various agencies of the United Nations for nationals of Latin America, either in unrestricted fields, agriculture, or nuclear science:

United Nations Agency	Number	Field
Food and Agriculture Organization	8–10	Agriculture, forestry, nutrition
International Atomic Energy Agency	11, Latin America to U.S.A.	Nuclear science
International Labor Office	1, L.A. to U.S.	Unrestricted
International Telecommunications Union	36–57 (2, L.A. to U.S.A., 1957)	Unrestricted

In late 1959 plans were being formulated, under the United Nations Special Fund, for the training of industrial instructors of various institutions in Argentina, Chile, and Peru, and for work with the agricultural faculties of the University of Cochabamba and the Practical Agricultural School of Bolivia.

2. *Pan American Union Programs*

In a previous article of this paper it was pointed out that the Pan American Union administers exchange fellowship programs for the Organization of American States. In addition, it awards an unspecified number of 5-year interest-free loans, under the Leo S. Rowe Fund, to enable Latin Americans to pursue studies of their own choice for one year in the United States. One Leo S. Rowe Memorial Fellowship is awarded annually to a national of an OAS member state for a period of one academic year to study science, public administration, social work or education in the United States. The Pan American Union also administers Rotary Foundation Fellowships for International Understanding. In 1959–1960 these permitted 15 Latin Americans to pursue unrestricted graduate work in the United States, and 3 appointees from the United States to study in Latin American countries in which Rotary Clubs are located. There are Rotary Clubs in all Latin American countries except Haiti. Grants under the Rotary plan averaged $2,600.

3. *Other Inter-American Exchange Programs*

There are at least 8 other inter-American organizations and agencies that

award fellowships and scholarships for the exchange of persons in Latin America and the United States. Of these, there are 2 worthy of mention in this paper as applying to engineering and architecture. One is the International Road Federation, from which 16 Latin Americans receive $2,600 each for 8 to 10 months of study in traffic engineering in the United States. The other is the Inter-American Institute of Agricultural Sciences, from which 779 Latin Americans receive tuition, maintenance, and travel costs for 4 to 8 weeks of agricultural studies in Latin American countries other than their own.

Directory of Organizations and Committees in UPADI Countries for Training in the United States

Persons in the United States who are interested in studying abroad or persons in the UPADI countries interested in studying in the United States are advised to communicate with the Institute of International Education. But there are also many other organizations and agencies, as well as committees, within all UPADI countries that provide information and assistance in connection with the procurement of fellowships and grants for study in the United States. A directory of these organizations and committees is presented in Appendix 3.

Recommendations and Conclusion

Several matters that have been brought to light in this paper would seem to deserve further discussion and possible action at this Congress.

First for consideration is the substantial increase of 44% in the number of foreign students, physicians, and visiting scholars that have come to the United States since 1955. The UPADI countries have contributed their normal share to this increase. The United States always, of course, welcomes foreign citizens to its colleges and universities as potential advocates of good will among nations. Any exchange program should, however, be examined carefully from time to time, to see that those individuals who are sponsored by it realize their obligation to return to their native lands for future service. Not all exchange programs impose a return limitation. Perhaps more of them should. The authors have no information on the number of foreign visitors in the United States who immediately or eventually take up their residence there and whose training is thus lost to their native countries. It is certain, however, that all countries lose many of those it seeks to train for service at home. This is regrettable.

Second, the authors would strongly recommend that Latin American countries give serious consideration to membership in the International Association for the Exchange of Students for Technical Experience, and that industrial companies of all UPADI countries with foreign affiliates or subsidiaries inaugurate or expand private educational exchange arrangements jointly with their allied companies and selected colleges and universities.

Third, with the approval of our good neighbors of the Western Hemisphere, we who represent the United States at this Congress would like to recommend that UPADI take whatever steps lie within its power to increase the annual number of U. S. students in Latin American colleges and universities, as well as the number of professors and scholars exchanged between the United States and UPADI countries. It has been pointed out that the number of U. S. students in Latin America decreased from 2,570 in 1956–1957 to 1,049 in 1957–1958, with no figures available for 1958–1959; and that in the fields of agriculture, engineering, and science only 51 professors and scholars went from the United States to all other UPADI countries in 1958–1959 and only 81 from UPADI countries to the United States.

The Organization of American States has recognized this situation and has already commenced remedial action. As previously stated, the OAS anticipates an eventual increase from 170 to 500 in the number of inter-American exchange fellowships and scholarships to residents of OAS member states for unrestricted study for periods of 3 months to 2 years. Moreover, a new professorship exchange program for the Western Hemisphere was

set up by the U. S. Department of State to commence on July 1, 1960. Grantees will receive $1,000 per month plus expenses for periods of 1 to 2 semesters.

Further stimulation of international educational exchange between Latin America and the United States may be effected by legislation pending at the time this paper was written. The State Department has requested an increase in the appropriation for educational exchange for the 1961 U. S. fiscal year beginning on July 1, 1960. Following is an excerpt from the text of a statement made in late February, 1960, in a hearing before a Subcommittee of the Appropriations Committee of the House of Representatives:

> The Commission on Education and International Affairs of the American Council on Education commends the Department of State for submitting, with the approval of the President, a budget request for international education programs which will make possible some much-needed steps forward in the commitment of the United States to international educational and cultural exchanges with other nations. The Commission notes that the request for an additional $5 million in unrestricted funds is made with the expectation of financing more exchanges with the nations of Africa, Latin America, the Near East, and the Far East.
>
> The Commission urges the Appropriation Committees of the Senate and the House of Representatives to approve the increase in the educational exchange appropriation from $23.2 million to $28.2 million, especially since this increase is proposed for dollars that can be spent without restriction as to country, thus giving the exchange program the flexibility of operation it needs.

In conclusion, the authors freely acknowledge their inability to give complete coverage to the vast scope of educational exchange among the UPADI countries. Many programs, particularly those of a private nature, have doubtless been overlooked. It is hoped, however, that this paper will furnish a basis for discussion.

Appendix 1

Private Organizations and Agencies of the United States Which Sponsored and Financed Exchange of Persons between the U. S. A. and Latin America in 1958–1959, in Agriculture, Engineering, and Physical and Natural Sciences

Altrusa International
American Association of University Women
American Federation of Soroptimist Clubs
Anaconda Copper Mining Company
Braniff International Airways
Carnegie Corporation
Catherwood Foundation
Cordell Hull Foundation
Creole Foundation
Creole Petroleum Corporation
Henry L. and Grace Doherty Charitable Foundation, Inc.
Eisenhower Exchange Fellowships, Inc.
Elias Ahuja Exchange Fellowships
Ford Foundation
John Simon Guggenheim Memorial Foundation
Institute of International Education
International House, New Orleans
Johnson Foundation
Kennecott Copper Corporation
Methodist Church, Board of Missions
Minnesota Mining and Manufacturing Company
Moa Bay Mining Company
National Academy of Sciences–National Research Council
Pan American Foundation, Inc.
Pan American Grace Airways
Pan American World Airways
Quota Club International
Refineria Panama International Scholarships
Rockefeller Foundation
Rotary Clubs and Districts
Rotary International
Socony-Mobil Oil Company
State of Texas
United Fruit Company
United Presbyterian Church
United States National Student Association
Williams Foundation
Women's Clubs, State Federations of

In addition, about 1500 colleges and universities of the United States participate in the country's exchange program in all areas of higher education. Appendix 2 lists 86 of these.

Appendix 2

Colleges and Universities of the United States That Reported 100 or More Foreign Students in Attendance During 1958–1959

Institution	Location	Number of Foreign Students
University of Arizona	Tucson, Arizona	165
California Institute of Technology	Pasadena, California	103
California State Polytech. College	San Luis Obispo, Calif.	157
University of California	Berkeley, California	1,046
City College of San Francisco	San Francisco, Calif.	124
Heald College	San Francisco, Calif.	175
Sacramento Jr. College	Sacramento, California	119
San Francisco State College	San Francisco, Calif.	159
University of San Francisco	San Francisco, Calif.	138
University of Southern California	Los Angeles, California	814
Stanford University	Palo Alto, California	341
University of Colorado	Boulder, Colorado	196
Yale University	New Haven, Connecticut	430
American University	Washington, D. C.	428
Catholic University	Washington, D. C.	221
Georgetown University	Washington, D. C.	369
George Washington University	Washington, D. C.	237
Howard University	Washington, D. C.	292
University of Florida	Gainesville, Florida	250
University of Miami	Coral Gables, Florida	243
Georgia Institute of Technology	Atlanta, Georgia	196
University of Chicago	Chicago, Illinois	407
Illinois Institute of Technology	Chicago, Illinois	114
University of Illinois	Urbana, Illinois	908
Northwestern University	Evanston, Illinois	239
Roosevelt University	Chicago, Illinois	161
Southern Illinois University	Carbondale, Illinois	172
Indiana Technical College	Fort Wayne, Indiana	212
Indiana University	Bloomington, Indiana	462
University of Notre Dame	Notre Dame, Indiana	139
Purdue University	Lafayette, Indiana	367
Iowa State College	Ames, Iowa	206
State University of Iowa	Iowa City, Iowa	175
Kansas State College	Manhattan, Kansas	147
University of Kansas	Lawrence, Kansas	196
Louisiana State University	Baton Rouge, Louisiana	414
Southwestern Louisiana Institute	Lafayette, Louisiana	118
Tulane University	New Orleans, Louisiana	182
Johns Hopkins University	Baltimore, Maryland	105
University of Maryland	Baltimore, Maryland	261
Boston University	Boston, Massachusetts	360
Harvard University	Cambridge, Massachusetts	716
Massachusetts Inst. of Technology	Cambridge, Massachusetts	762
Calvin College	Grand Rapids, Michigan	136
Detroit Institute of Technology	Detroit, Michigan	100
University of Detroit	Detroit, Michigan	199
Eastern Michigan College	Ypsilanti, Michigan	107
General Motors Institute	Flint, Michigan	112
Michigan College of Mining & Tech.	Houghton, Michigan	227
Michigan State University	East Lansing, Mich.	389
University of Michigan	Ann Arbor, Michigan	1,139
Wayne State University	Detroit, Michigan	225
University of Minnesota	Minneapolis, Minnesota	1,136
University of Missouri	Rolla, Missouri	299

Institution	Location	Number of Foreign Students
St. Louis University	St. Louis, Missouri	127
Washington University	St. Louis, Missouri	116
University of Nebraska	Lincoln, Nebraska	177
Princeton University	Princeton, New Jersey	208
Rutgers University	New Brunswick, New Jersey	103
Columbia University	New York, New York	1,380
Cornell University	Ithaca, New York	708
Fordham University	New York, New York	166
New York University	New York, New York	1,670
Rensselaer Polytechnic Institute	Troy, New York	197
Syracuse University	Syracuse, New York	216
University of North Carolina	Chapel Hill, N. C.	276
University of North Dakota	Grand Forks, North Dakota	120
University of Cincinnati	Cincinnati, Ohio	124
Ohio State University	Columbus, Ohio	397
Oklahoma State University	Stillwater, Oklahoma	246
University of Oklahoma	Norman, Oklahoma	179
Oregon State College	Corvallis, Oregon	225
University of Oregon	Eugene, Oregon	205
Pennsylvania State University	University Park, Pa.	145
University of Pennsylvania	Philadelphia, Pa.	301
University of Pittsburgh	Pittsburgh, Pa.	155
University of Houston	Houston, Texas	149
Southern Methodist University	Dallas, Texas	100
Texas A. & M.	College Station, Texas	230
University of Texas	Austin, Texas	542
Brigham Young University	Provo, Utah	266
Utah State University	Logan, Utah	197
State College of Washington	Pullman, Washington	170
Marquette University	Milwaukee, Wisconsin	104
University of Wisconsin	Madison, Wisconsin	722
University of Hawaii	Honolulu, Hawaii	123
University of Puerto Rico	Rio Piedras, Puerto Rico	108

Appendix 3

Organizations and Committees in the UPADI Countries on Study and Training in the United States

In All Countries

Minister of Education, in the country's capital

In Argentina

Instituto Cultural Argentino-Norteamericano, Maipú 686, Buenos Aires

Instituto de Intercambio Cultural Argentino-Norteamericano, Caseros 51, Córdoba

Amicana, Godoy Cruz 178, Mendoza

Asociación Rosarina de Intercambio Cultural Argentino-Norteamericano, Sarmiento 548, Rosario

Committee on Study and Training in the United States, Tucumán 3041, Santa Fe

Committee on Study and Training in the United States, Salta 940, Tucumán

In Bolivia

Centro Boliviano-Americano, Avenida 6 de Agosto 610, La Paz

In Brazil

American Consulate, Belém, Pará

Centro Cultural Inter-Americano, Avenida João Pessoa 103, 7° Andar, Curitiba, Paraná

Instituto Brasil-Estados Unidos, Caixa Postal 217, Florianopolis, Santa Catarina

Instituto Brasil-Estados Unidos no Ceará, Rua Salon Pinheiro 68, Fortaleza Ceará

Instituto Cultural Brasileiro-Norteamericano, Avenida Borges de Medeiros 261, Edificio Uniao, 12° Andar, Porto Alegre

Sociedade Cultural Brasil-Estados Unidos, Rua Sete de Setembro, No. 454, Recife, Pernambuco

Instituto Brasil-Estados Unidos, Rua Senador Vergueiro 103, Rio de Janeiro

Associacão Cultural Brasil-Estados Unidos, Largo da Vitória 6, Salvador, Bahia
União Cultural Brasil-Estados Unidos, Rua Santo António 487, São Paulo

In Canada

Deputy Minister, Department of Education, Parliament Buildings, Toronto, Ontario, Canada

In Chile

Instituto Chileno-Norteamericano de Cultura, Moneda 1467, Santiago
Instituto Chileno-Norteamericano de Cultura, Caupolicán 81, Concepción
Instituto Chileno-Norteamericano de Cultura, Esmeralda 1061, Valparaíso

In Colombia

Centro Colombo-Americano, Carrera 7.ª n.° 23-49, Bogotá
Centro Colombo-Americano de Medellín, La Playa 43-76, Medellín

In Costa Rica

Centro Cultural Costarricense-Norteamericano, Casa 539, Avenida Central, Apartado 1489, San José

In Cuba

Instituto Cultural Cubano-Norteamericano, Calzada n.° 308, Vedado, La Habana

In Dominican Republic

Instituto Cultural Dominicano-Americano, Avenida Pasteur 48, Ciudad Trujillo

In Ecuador

Centro Ecuatoriano - Norteamericano de Guayaquil, calle Luque 136, Guayaquil
Centro Ecuatoriano-Norteamericano de Relaciones Culturales, edificio Ejido, avenida 10 de Agosto 817, Quito

In El Salvador

Committee on Study and Training in the United States, calle Arce No. 91 San Salvador

In Guatemala

Instituto Guatemalteco-Americano, 13 Calle 2-52, Guatemala City

In Haiti

Institut haitiano-américain, avenue Boyer, Port-au-Prince

In Honduras

Instituto Hondureño de Cultura Interamericana, Apartado Postal 201, Tegucigalpa

In Mexico

Instituto Mexicano-Norteamericano de Relaciones Culturales, Hamburgo 115, Mexico, D.F.
Instituto Cultural Mexicano-Norteamericano de Jalisco, A. C., Tolsa 300, Guadalajara, Jalisco
Instituto Mexicano-Norteamericano de Relaciones Culturales, Hidalgo Pte. 317, Monterrey

In Nicaragua

Committee on Study and Training in the U. S., Apartado de Correo 370, Managua

In Panama

Instituto Panamericano, Box 1037, Panama City

In Paraguay

Centro Cultural Paraguayo-Americano, Avenida España 494, Asunción

In Peru

Instituto Cultural Peruano-Americano, Jirón Antonio Miró Quesada 113, Lima

In United States

Institute of International Education, 1 East 67th Street, New York 21, New York

In Uruguay

Committee on Study and Training in the United States, Biblioteca Artigas-Washington, Calle Yi, 1327, Montevideo

In Venezuela

Cultural Affairs Officer, American Embassy, Caracas

NEW SCHOOL OF ENGINEERING AT SANTA BARBARA

A new school of engineering at the University of California's Santa Barbara campus has been authorized by the Regents of the university. The new school is expected to open its doors to the first students next fall.

The announcement by U. C. President Clark Kerr and Chancellor Samuel B. Gould marks the establishment of the first professional school on this campus.

The initial steps in beginning this professional engineering school will include the selection of a dean of the school who will work out the details of the curriculum in consultation with the Academic Senate Committees.

The new engineering school will offer the bachelor of science degree in engineering with graduate degrees to be added at a later date, Chancellor Gould explained.

What's Going on in ASEE

A Narration of Major Actions of the Executive Board and General Council Meetings, September and November, 1960

W. Leighton Collins, Secretary, ASEE

For the past two years there has been much discussion about ASEE's constantly increasing number of special studies, summer schools, etc., and their sound planning and financing. Last June it looked as though the Ford Foundation would provide the extensive financial help needed, and three programs were submitted to it for consideration. But in November the story was different—ASEE gets nothing! Thus the "Evaluation of Technical Institute Education," the "Study of Off-Campus Graduate Work," and the financing of the new "Projects Management Group" have been delayed. New sources for financial support now must be sought. The interest of the National Science Foundation in doing something really big or broadly inclusive for engineering education is being carefully investigated.

The Society has forwarded a resolution to the National Science Foundation requesting the establishment of a "Division for Engineering Science," separate and distinct from mathematics and physics, with which engineering has been associated up to the present time. The resolution originated in ECRC because of the belief that research in the engineering sciences has progressed to such an extent that a separate division administered by engineers is justified. Other organizations such as EJC and ECPD are being asked to support the request.

The Projects Management Group has held its first meeting and is organized. In addition to the three projects already mentioned, the proposal of the English Division for a joint study with the American Management Association of what business expects to find in its technical reports, the three-year $100,000 project of the Electrical Engineering Division for the visiting lecturer program on the newer and/or advanced fields of electrical engineering, the Conference of Mechanics Teachers sponsored about every five years by the Mechanics Division, and the Chemical Engineering Teachers' Workshop are being referred to PMG for approval. PMG also is to initiate proposals, so the need for the permanent financing of its activities is imperative.

The request of the Engineering Economy Division for a summer school in conjunction with the 1962 Annual Meeting was approved.

The request of the Industrial Engineering Division for a two-day summer school jointly sponsored by the Division and ASTME, with ASTME underwriting the cost, in conjunction with the 1961 Annual Meeting was approved.

In taking a look at what is ahead, the financial needs of the Society for 1961-62 present some real problems. The Executive Board reviewed the data submitted by the Secretary to serve as the basis for submitting a tentative budget at the February meeting. A drastic revision of the dues structure for institutional members, at least, seems imperative if a balanced budget is to be maintained and if the headquarters staff is to meet the continually growing demands placed upon it and required for ASEE to be "the voice of engineering education."

The annual audit distributed at the September Executive Board meeting and to be published in the *Yearbook-Directory* indicated that 1959–60 was another good year and that the financial soundness of the Society continued to improve. The financial report for the first quarter

indicates that income and expenditures are closely following the pattern of past years and are in general accord with the budget.

The individual membership drive this year is under the direction of the Vice Presidents for Sections. They have written the deans of engineering at member institutions and at over 100 schools there now are live-wire membership chairmen with adequate supplies of brochures and application forms. Particularly at large schools, the efforts of many are needed. To date, the number of new members is running slightly behind the average for the past three years.

The Industrial Membership Committee is concentrating on a list of about 500 large corporations. A letter of invitation from President Walker has been sent to each and the committee members will follow up as needed. Some individuals also are making valuable personal contacts in their areas.

The Executive Board approved Boston University, Lincoln University, and Tuskegee Institute as affiliate members.

The "little house" occupied by ASEE as its headquarters has been modified by the University of Illinois to provide more work space. The interior also has been redecorated. The improvements were badly needed and are appreciated by the entire staff. The Executive Board approved the immediate employment of an additional person to give some relief to the work load of the Secretary and Office Secretary, and endorsed the idea of employing the Assistant Secretary on a half-time basis throughout the year instead of only for the academic year.

ECRC reports that it has elected Rice University to membership, that it will charge $4.00 for the 1961 Research Review, that it is reviewing new membership applications on the basis of new standards—the participation of the teaching staff in research rather than merely the dollar value of the work being done, and that a committee has been appointed to determine the value of undergraduate research experience and how commonly such programs are being carried out.

The Pacific Southwest Section is proceeding with its plans to develop an industry-education program. It is believed the needed funds can be raised locally, as previously agreed to, with both educational institutions and industry contributing.

The Mechanical Engineering Division reported that the subscriptions to its publications ($1.00 per year) were insufficient to meet costs. A request has been made to the Secretary suggesting a dues increase of 60¢ per year per member for divisional publications.

The General Council voted that the resolution of the Graduate Studies Division should be widely distributed, as requested by the Division. The full text of the resolution follows:

ASEE GRADUATE STUDIES DIVISION

Resolution

Whereas, the lead time between a scientific discovery and its industrial application is constantly decreasing, and

Whereas, the demand for and enrollment in engineering graduate programs have increased markedly since World War II, and

Whereas, engineering undergraduate curricula have been increasing in common core content, in scientific scope, and in length during the past several decades, and

Whereas, a definite need has now developed for engineers educated for the professional practice of engineering including design and production, or for development and research, and

Whereas, individuals suited for either professional practice or for development and research usually differ markedly in temperment and motivation, and

Whereas, the engineering profession, the civilian economy, and the defense effort badly need engineers of both such types educated on a doctoral level, now, therefore,

Be It Resolved, that the Graduate Studies Division of the American Society for Engineering Education hereby urges the establishment of separate programs leading to the degrees of Master of Engineering and Doctor of

Engineering in the several specialties, and

Be It Further Resolved, that the Graduate Studies Divisions also favors the continuation of current university graduate programs leading to the Master of Science and Doctor of Philosophy (Ph.D.) degrees in the several engineering specialties, and

Be It Further Resolved, that a copy of this resolution be forwarded by the Secretary of the American Society for Engineering Education to all engineering schools, the Engineering Founder Societies, and State Boards of Engineering Examiners in the United States.

Vice President Hall reviewed the problems being faced by ECPD regarding graduate work, and it was agreed he should see that a statement of the difficulties be sent to President Walker so that they can be considered in the light of the proposed off-campus study.

In discussing programs of the International Engineering Education Committee the need for appropriate programs for foreign students was considered. It was voted by the General Council that the Committee appoint a small group to find out what really is being done in our colleges of engineering to adapt programs to the student's needs in his native country.

The Visiting Scientist programs of NSF—for high schools, colleges, and universities and for foreign visitors—were discussed in order to get some idea of the extent to which ASEE should participate. There was a significant lack of enthusiasm for a foreign visitor's program, but the Secretary was instructed to explore what could be developed for high school visitations. The current program for visits to junior colleges, small liberal arts colleges, etc. is being extended to July 1, 1961, provided NSF grants additional funds.

The request of Worcester Polytechnic Institute for ASEE to cosponsor its program on Research Goals was approved.

An ad hoc Printing Economy Committee has been appointed to study the cost of printing the JOURNAL and recommend a change of printer if it is desirable. The reasons are the increase in cost of 5.8% for this year, the fact that the Yearbook-Directory is being printed separately this year for economic reasons, and because the last such study was made five years ago.

The request from ECPD for a study of the effect of Junior College programs on engineering education was referred to the Guidance Committee of ECAC for study along with instructions to cooperate with ECPD and to submit a report on what should be done.

There was much discussion of YETs at the Executive Board meetings. It was suggested that perhaps "New Engineering Teachers" might be a better classification and afford a better basis for useful programing on both the local and Section levels. Suggestions for how to get more such people to the Annual Meeting are welcome.

The next meeting of the Executive Board will be held on February 7, 1961 in Chicago, and both the Executive Board and the General Council will meet during the Annual Meeting at the University of Kentucky.

These are the highlights of the Executive Board meetings on September 21 and November 16 and the General Council meeting on November 16.

NUCLEAR PH.D. AT ILLINOIS

An advanced educational program leading to the Doctor of Philosophy degree in nuclear engineering has been established at the University of Illinois. Action on the new program came two years after the University's initiation of nuclear engineering at the master's degree level.

During that period 13 degrees have been awarded and physical facilities have come to include the Illinois TRIGA nuclear reactor, three sub-critical assemblies, a heat transfer loop, a radio chemistry laboratory and a nuclear metallurgy laboratory. The reactor began operation last July.

Teaching Positions Available

PHYSICIST TO HEAD DEPARTMENT of Physics in undergraduate area of engineering curricula. Opportunity available to teach advanced elective courses and in research. Ph.D. preferable but not essential. Write to Dean, School of Engineering, The Cooper Union, New York 3, N. Y.

INDUSTRIAL ENGINEERING—ASsistant or Associate Professor depending upon qualifications. M.S. required, Ph.D. and/or P.E. desirable. To teach and develop area of Process Engineering, Tool Design. Start September 1, 1961. Write H. L. Manning, Head of Department of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Virginia.

TEACHING VACANCIES EXIST FOR undergraduate courses in Mechanics, Thermodynamics, Materials, in young Engineering Department. Minimum requirement—Masters Degree. Rank and salary dependent on qualifications. Write –Jack Bordan, Head, Department of Engineering, Sir George Williams University, Montreal 25, Canada.

TEACHING POSITION—IMMEDIATE opening in hydraulic engineering. The undergraduate course is given in French. Ability to lead research programs for the graduate school. Hydraulic engineering experience and advanced degree required. Apply in French: Head, Department of Civil Engineering, Laval University, Quebec, Canada.

MECHANICAL ENGINEERING. MAN required in the machine design area starting September 1, 1961. Excellent opportunity to teach and direct undergraduate and graduate programs. Develop courses and research for a new Cooperative Ph.D. program which is sponsored heavily by local industries and a sizeable foundation grant. Salary and rank will depend on educational background and experience. Write to J. W. Bunting, Head, Mechanical Engineering Department, University of Cincinnati, Cincinnati 21, Ohio.

MECHANICAL ENGINEERING teaching and research positions in heat transfer-thermodynamics and materials science. Attractive opportunities are available due to departmental expansion. Ph.D. required. Write to Donald M. Vestal, Jr., Head Professor, Mechanical Engineering, Auburn University, Auburn, Alabama.

TWO OPENINGS IN MECHANICAL engineering for young Ph.D.'s—one in thermodynamics-heat transfer and one in design. Research opportunities. Walter J. Seeley, Dean, College of Engineering, Duke University, Durham, North Carolina.

EXPERIENCED PH.D. IN APPLIED Mechanics. Principally for graduate instruction and research, rank to be determined on basis of qualifications. Also teacher with advanced degree for undergraduate mathematics and mechanics. Opportunity for taking graduate work. Apply to Professor R. E. Hundley, Professor of Mechanics, University of Cincinnati, Cincinnati 21, Ohio.

ELECTRICAL ENGINEERING teaching positions open in the areas of circuits, microwaves, and electromagnetics. Ph.D.'s preferred. One opening starting February and another opening starting September, 1961. Possibilities for research and consulting. Send resume to L. J. Galbiati, Dept. of Elect. Engr., Merrimack College, North Andover, Massachusetts.

GENUINE OPPORTUNITY FOR Young Ph.D.'s—electrical, mechanical, metallurgical—who have drive and imagination and would like to assist in development of a growing research and graduate program as well as teach. Accredited undergraduate curricula, midwestern university located in industrial area, 10 month or 12 month appointments, rank and salary commensurate with qualifications. Effective July 1 or September 1, 1961. Write to 51-5, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

OVERSEAS. ROBERT COLLEGE, IN Istanbul, Turkey, presents a challenge in education in a vital part of the world. West and Middle East are contributing side by side to the development of a young and vigorous nation. Opportunities are available in engineering, business administration and economics, the sciences, and the humanities. Graduate degrees required. Address inquiries to Dr. Howard P. Hall, Dean of Faculty, Robert College, Bebek Post Box 8, Istanbul, Turkey; with copy to the Near East College Association, 548 Fifth Avenue, New York 36, New York.

CIVIL ENGINEERING ASSISTANT or Associate Professor. A man with highway and soil mechanics experience both in practice and in teaching. A doctor's degree is desired, but training of one year beyond the master's degree and ability to guide graduate student research work in soil mechanics should be minimum. Start September 1, 1961. Write to Professor William S. La Londe, Jr., Chairman, Civil Engineering Department, Newark College of Engineering, 323 High Street, Newark 2, New Jersey.

TEACHING AND RESEARCH. OPENing for Electrical Engineer with Ph.D. to supervise graduate research and do some teaching. Research experience in microwaves or semiconductors desirable. Private research or consultation encouraged. Excellent salary and rank arrangements. Department offers work leading to Ph.D. Position available September 1961 or sooner. Apply to Chairman, Electrical Engineering Department, Vanderbilt University, Nashville 5, Tennessee.

PROFESSOR OR ASSOCIATE PROfessor—to teach courses in aerospace and mechanical engineering at both undergraduate and graduate levels and direct graduate research. The new expanding graduate (65 full-time graduate students) and research program will require applicants to have Ph.D. or equivalent. Rank and salary will depend on qualifications. Address inquiries and send personal data to H. D. Christensen, Head, Mechanical Engineering Department, University of Arizona, Tucson, Arizona.

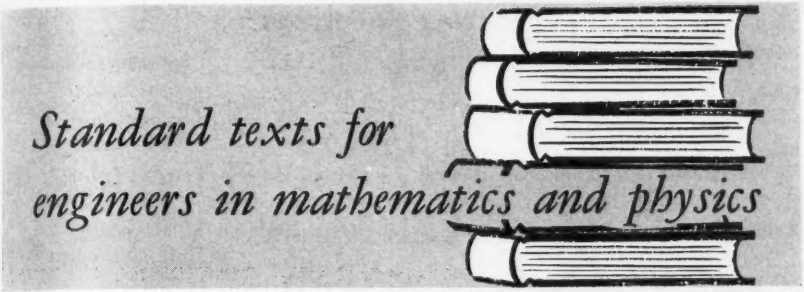
ASSISTANT PROFESSOR TEACHING position in Mechanical Engineering Department, University of Nevada, Reno, Nevada, available in fall 1961. M.S. degree in M.E. and some additional experience is desired. Write to chairman.

MECHANICAL ENGINEERING—ASsistant or Associate Professor with specialty in either Thermodynamics or Machine Design. Advanced degree required and design office or industrial research experience desirable. Also expect to have one or two openings for junior staff. Applications with full particulars should be sent to Head, Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, Sask., Canada.

MECHANICAL ENGINEERING teaching position starting September 1961. Man with Ph.D. (preferred) or Master's Degree whose field of specialization is either fluid mechanics, heat transfer and thermodynamics or machine design and stress analysis. New engineering school with excellent facilities. Salary and rank will depend upon qualifications. Apply to: Chairman of the Division of Engineering, Sacramento State College, Sacramento 19, California.

THE ELECTRICAL ENGINEERING Department of The City College of New York has several positions available on the teaching staff beginning September 1961. Rank and salary commensurate with qualifications and experience. Opportunity for graduate study. Applicants must be present residents of the United States. Address inquiry to Prof. H. Taub, Dept. of Electrical Engineering, The City College, Convent Ave. at 139th Street, New York 31, N. Y.

MECHANICAL ENGINEERING. EXcellent opportunities for persons qualified in industrial engineering, thermodynamics, gas dynamics, heat transfer, fluid mechanics, nuclear engineering, mechanics of solids, or automatic control theory. Rank and salary dependent on qualifications. Research and consulting encouraged. Write to S. Mercer, Jr., Head, Mechanical Engineering Department, Drexel Institute of Technology, Philadelphia 4, Pa.



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Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny		April, 1961	E. R. Schatz, Carnegie Institute of Technology
Illinois-Indiana	Ill. Inst. of Tech.	May 13, 1961	Peter Chiarulli, Ill. Inst. of Tech.
Kansas-Nebraska	Kansas State U.	Oct., 1961	M. H. Snyder, Univ. of Wichita
Michigan	Michigan State U.	April 22, 1961	C. E. Cutts, Mich. State Univ.
Middle Atlantic	Drexel Inst. of Tech.	Dec. 3, 1960	F. L. Singer, New York Univ.
Missouri-Arkansas	Saint Louis Univ.	April 8, 1961	V. T. Allen, Saint Louis Univ.
National Capital Area		Jan. 10, 1961	Geo. H. Hickox, Ft. Belvoir, Va.
New England	Brown University	Oct., 1961	E. F. Littleton, Tufts Univ.
North Midwest	Marquette Univ.	Oct., 14–15, 1960	R. J. Kipp, Marquette Univ.
Ohio	Ohio State Univ.	April, 1961	R. S. Green, Ohio State Univ.
Pacific Northwest	Univ. of Washington	May, 1961	H. P. Mittet, Univ. of Washington
Pacific Southwest	Stanford University	Dec. 28–29, 1960	R. J. Parden, U. of Santa Clara
Rocky Mountain	University of Wyoming	Apr. 28–29, 1961	A. J. McGaw, Univ. of Wyoming
Southeastern	Univ of Mississippi	April 20–21, 1961	W. J. Seeley, Duke Univ.
Southwest	Univ. of Tulsa	Apr. 7–8, 1961	G. B. Tims, Jr., Lamar State College
Upper N. Y.-Ontario	Clarkson College	Oct. 1961	R. D. Larsson, Clarkson College

Mid-Winter Meetings–1961

Cooperative Education — Jan. 23–25 — University of Detroit

Information: D. C. Hunt, Director of Coordination and Placement, University of Detroit, Detroit, Mich.

Engineering Graphics — Jan. 19–21 — University of Wichita

Information: A. C. Risser, Head, Engineering Drawing, University of Wichita, Wichita, Kansas

College-Industry Conference — Feb. 2–3 — University of Cincinnati

Information: C. Wandmacher, Assoc. Dean of Engineering, University of Cincinnati, Cincinnati, Ohio

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SYSTEMS: RESEARCH AND DESIGN
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Edited by Donald P. Eckman, *Case Institute of Technology.* All the authors of this book are prominent in the field of systems engineering. For the most part, the discussions pertain to analysis and synthesis in very large complex systems such as industrial manufacturing complexes, military systems, economic systems, and systems involving both men and machines. The basic topics touched upon involve systems theory, communication, control, performance criteria, optimization, reliability, and human functions in the systems. Six of the fourteen authors are from industry, and their articles include a number of practical industrial applications. *1961. In press.*

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An Introduction into the Thinking in and the Use of Ferrites and High ϵ Dielectrics

By H. M. Schlicke, *Allen-Bradley Co.* This book is written for the inquisitive electronics engineer and advanced engineering student looking for facts and stimuli about the possibilities and limits inherent in magnetically soft ferrites and high ϵ dielectrics. These magnetic and/or dielectric polycrystalline ceramics play an ever increasing role in modern electronic circuits. After many years of experience in the evaluation and application of this role, the author has been able to produce a text of paramount interest to actual and potential users of these materials, and a valuable reference written in the language of the electronics engineer. *1961. Approx. 272 pages. Prob. $8.50.*

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By A. S. Hall *and* R. W. Woodhead, *both of the University of New South Wales.* This book deals with the mathematical analysis of structural frames. The treatment is limited to frames in which displacements are small and in which the load displacement relationship is linear. It is not limited to simple frames, however, and deals with three dimensional frames containing curved members and members of varying cross-sections. The principal philosophy of the book is the presentation of the subject as a unified whole. After introductory material which outlines the basic concepts, the book is divided into two distinct parts dealing respectively with flexibility analysis and stiffness analysis. *1961. Approx. 264 pages. In Press.*

ADVANCED CALCULUS

An Introduction to Analysis

By Watson Fulks, *Oregon State College. Advanced Calculus* is designed to serve as an introduction to analysis. To this end the author has tried to present analytical proofs backed by geometrical intuition with a minimum of reliance on geometrical arguments. The result is a textbook with emphasis placed on (1) clarity of exposition, (2) development of the students understanding and appreciation of mathematics, and (3) complete coverage of materials basic to the intended purpose. The book is divided into three main sections which treat, respectively, a re-examination of one variable calculus from a rigorous point of view, calculus of several variables with the extensive use of vector notation methods, and the theory of convergence as applied to series and improper integrals. *1961. Approx. 552 pages. Prob. $9.50.*

PROGRESS IN OPERATIONS RESEARCH: VOLUME I

Edited by Russell L. Ackoff, *Case Institute of Technology, with 12 Contributors.* This represents the inauguration of a series of review volumes which will inventory mathematical techniques and research methods available to operations researchers. The series has been designed to provide books which will serve as basic reference material to which OR practitioners or students may turn for reliable, up-to-date information on major OR techniques. The articles to be included in the various volumes will be contributed, upon editorial invitation, by leading experts in the field. The primary emphasis of Volume I is on the technical progress (i.e. the development of modelling techniques and their application to problem-solving) in the most important areas of OR. *1961. Approx. 480 pages. Prob. $9.75.*

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By J. H. Westing *and* I. V. Fine, *both of the University of Wisconsin, and by* Members of the Milwaukee Association of Purchasing Agents Affiliated with The National Association of Purchasing Agents. Purchasing policies, instead of procedures, receive major attention in this new edition. New information is also given on such changing areas as: the materials management concept of organization; coping with the rising cost of transportation; value analysis; quality and quantity control procedures; and anti-trust and administered pricing. All facts and figures are up to date. *1961. Approx. 576. Prob. $7.75.*

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Return to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Ill.

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Humanities and Social Sciences
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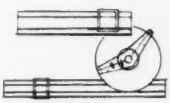

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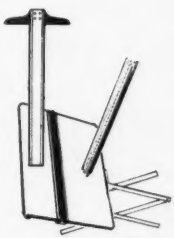

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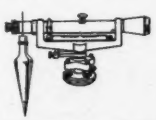

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